ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 189909

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. Date
Supplemental [] Direct Revision [x] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	J. A. Locklair, Environmental Restoration Safety Support, H4-67, 6-4409	June 25, 1993
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		7. Impact Level: 2 ESQ
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.): WHC-SD-EN-SAD-005, REV. 0	9. Related ECN No(s).: N/A
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12. Description of Change

Changes expand the soil washing system to include the 100 and 300 Areas.

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13a. Justification (mark one)							
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As-Found	[]	Facilitate Const.	[]	Const. Error/Omission	[]	Design Error/Omission	[]

13b. Justification Details

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15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
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[X] No	Savings	[] $	Savings	[] $	Delay	[]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]		[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog Engineer G. C. Henckel III	8/19/93	PE	
Cog. Mgr. W. L. Johnson	8/19/93	QA	
QA T. L. Bennington	8/23/93	Safety	
Safety M. A. Tredway	8/20/93	Design	
Security N/A		Environ.	
Environ. K. A. Gano	8/19/93	Other	8/22/93
Projects/Programs N/A		Radiation K. A. Smith	
Tank Waste Remediation System N/A		Ind. Safety L. C. Haslam	8/20/93
Facilities Operations N/A		DEPARTMENT OF ENERGY	
Restoration & Remediation N/A		Signature or Letter No.	
Operations & Support Services N/A			
IRM N/A		ADDITIONAL	
Other ERSS N. R. Kerr	8/20/93		
RRSA J. J. Zimmer	8/20/93		

Date Received: 9/27/93

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Reference: WHC-CM-3-4

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WHC-SD-EN-SAD-005, REV. 1

List attachments.
Appendixes A, B, C, and D

Date Release Required
June 30, 1993

Title: Soil Physical Separations Treatability Safety Assessment for 100 and 300 Areas

Unclassified Category: UC-

Impact Level: 2 ESQ

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J. A. Locklair J. A. Locklair 6/24/93

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7. Abstract

Potential hazards are addressed in this assessment and operational safety limits are provided to assure safe operation of soil physical separation treatment activities at the Hanford Site.

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9. Impact Level 2 ESQ

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RECORD OF REVISION	(1) Document Number WHC-SD-EN-SAD-005	i Page

(2) Title
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CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
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1	Changes expand the soil washing system to the 100 and 300 Areas.	G. C. Henckel III	W. L. Johnson

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SOIL PHYSICAL SEPARATIONS TREATABILITY SAFETY ASSESSMENT FOR 100 AND 300 AREAS

1.0 INTRODUCTION AND SUMMARY

A considerable amount of waste products has accumulated since the beginning of the Hanford Project. This waste has been disposed of in over 1,400 locations at the Hanford Site. An agreement, the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), was reached in 1989 among the U.S. Department of Energy (DOE), the Washington State Department of Ecology, and the U.S. Environmental Protection Agency on an approach to cleanup the Hanford Site (Ecology et al. 1990). To meet the provisions of that agreement, different methods are being considered to cleanup and reduce the volume of contaminated material from these waste sites.

Potential hazards are addressed in this assessment and operational safety limits are provided to assure safe operation of soil physical separation treatment activities at the Hanford Site. The radiological and chemical hazards associated with removal of contaminants from Hanford Site soils and the risks pertinent to that process are addressed in this document. This activity will assess the effectiveness of separation equipment and techniques using water and/or chemicals as a method to partition contaminated material from the soil. The purpose of the treatment activities is to reduce the volume of contaminated soil fines that must be disposed of in permanent waste repositories.

This safety assessment satisfies the requirements of WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual* and U. S. Department of Energy Order 5481.1B, *Safety Analysis and Review System* (DOE 1986). The rigor of review for this document is expected to be commensurate with the hazard classification.

1.1 ASSESSMENT SUMMARY

The radiological and toxicological dose consequences for this nonreactor nuclear activity are consistent with the criteria for low hazard activities (WHC-CM-4-46; Schade 1991). The technical inventory bases for the radiological and toxicological calculations that document the low hazard classification are from sample analyses for the 300 Area Process Trenches taken in 1986 (Zimmerman and Kossik 1987). Also included are the data from samples taken in 1992. The 100 Area base data were extracted from Dorian and Richards (1978). The wind erosion source term is based on the highest resuspension factors ever measured for the Hanford Site (3.5×10^{-6} per second). The concentrations are not expected to result in hazardous exposures to onsite workers (located a distance of 100 m [330 ft])and are anticipated to be well below the limits for a low hazard operation. All potential airborne concentrations are postulated to be below risk acceptance criteria for onsite and offsite individuals. Nuclear criticality is not a concern because of the small amount of fissionable material present. The determination is the bounding concentration and source term for activities being performed at (1) the 100 Area liquid waste sites; (2) the 300 Area north process pond; and (3)

the north end of the 300 Area west process trench. Excluded from the 100 Area waste site evaluations are the 1301-N and 1325-N crib concentrations.

Normal jobsite worker safety requirements contained in the Hazardous Waste Operations Permit (HWOP), Job Safety Analysis (JSA), and Radiation Work Permit (RWP) will provide adequate occupational safety, respiratory, and skin protection for the facility worker performing the soil washing activity. There is one prudent action (Section 4.2) that requires appropriate Westinghouse Hanford Company (WHC) safety approval of these three worker safety documents. Conformance to this action is verified during the readiness review process.

1.2 SUMMARY OF LIMITS AND PRUDENT ACTIONS

There are no unacceptable impacts anticipated from the treatment activities. However, controls will be applied to the described activities to minimize environmental impact and reduce exposures to as low as reasonably achievable (ALARA). Two operational safety limits (OSL) are provided to assure conformance with the requirements for a low hazard activity and for ALARA purposes. These OSLs apply to the control of fugitive dust and the storage of effluent liquid and soil. Environmental Engineering management has adopted three prudent actions that further reduce potential hazardous material exposures to ALARA.

The following are summaries of the OSLs.

1. The potential for fugitive dust shall be minimized throughout the activity. The hazardous material inventory and anticipated air concentrations are expected to be low. Because material might become dry during nonwork times and transportation, the OSL requires that soil material be maintained wet or other acceptable methods of stabilization used to mitigate emission of particles throughout the process and transportation. Because unstabilized soil might permit emissions of fugitive dust, the OSL further requires that separation processing cease if soil is not properly stabilized. Mitigation actions shall be applied before restart of separation processing.

2. The storage of contaminated soil and effluent liquid must be in a manner that minimizes the potential for their release to the environment. Although the hazard material inventory is low, unmonitored storage over an extended time could allow the effect of temperature and atmospheric extremes to cause the release of hazardous material to the environment. The OSL requires that liquid and soil waste be stored in a manner to prevent their release to the environment (excluding evaporation). Containment of this waste shall be periodically assessed and if required, prompt action taken to stabilize and maintain safe storage.

The following are summaries of the prudent actions.

1. Equipment removed from the work site will be monitored to assure it is free of radiological contamination and controlled in accordance with WHC requirements.

2. A disposal plan will be developed and implemented to remove the contaminated material (fines) to a permanent waste repository on the Hanford Site.

3. The potential generation of dust from the loading process may be minimized by construction of wind screens at the hopper (grizzly feeders).

4. Activity operations will be conducted in compliance with the HWOP, JSA, RWP, and WHC-CM-7-7, *Environmental Investigations and Site Characterizations*.

2.0 HANFORD SITE DESCRIPTION

This section provides a categorical list of references for detailed studies on the regional background of the Hanford Site.

- Meteorology - Delaney et al. (1991) and PNL 1990
- Geology - Delaney et al. (1991)
- Hydrogeology - Liikala et al. (1988).

There are no permanent residents on the Hanford Site. The working population of the 100 Area complex varies on a daily basis; generally, however, the average is 150 people per day. There are boaters who use the Columbia River for recreation throughout the year and have access to the west and south banks of the river. The nearest public road is State Highway 24, located 1.4 km (0.88 mi) from the closest 100 Area. The nearest resident to a 100 Area facility is located 8.1 km (5 mi) east of the 100-F Reactor Building and across the Columbia River. The west bank of the Columbia River is located about 275 m (900 ft) and 330 m (1,080 ft) from the work locations at the process pond and the process trench, respectively.

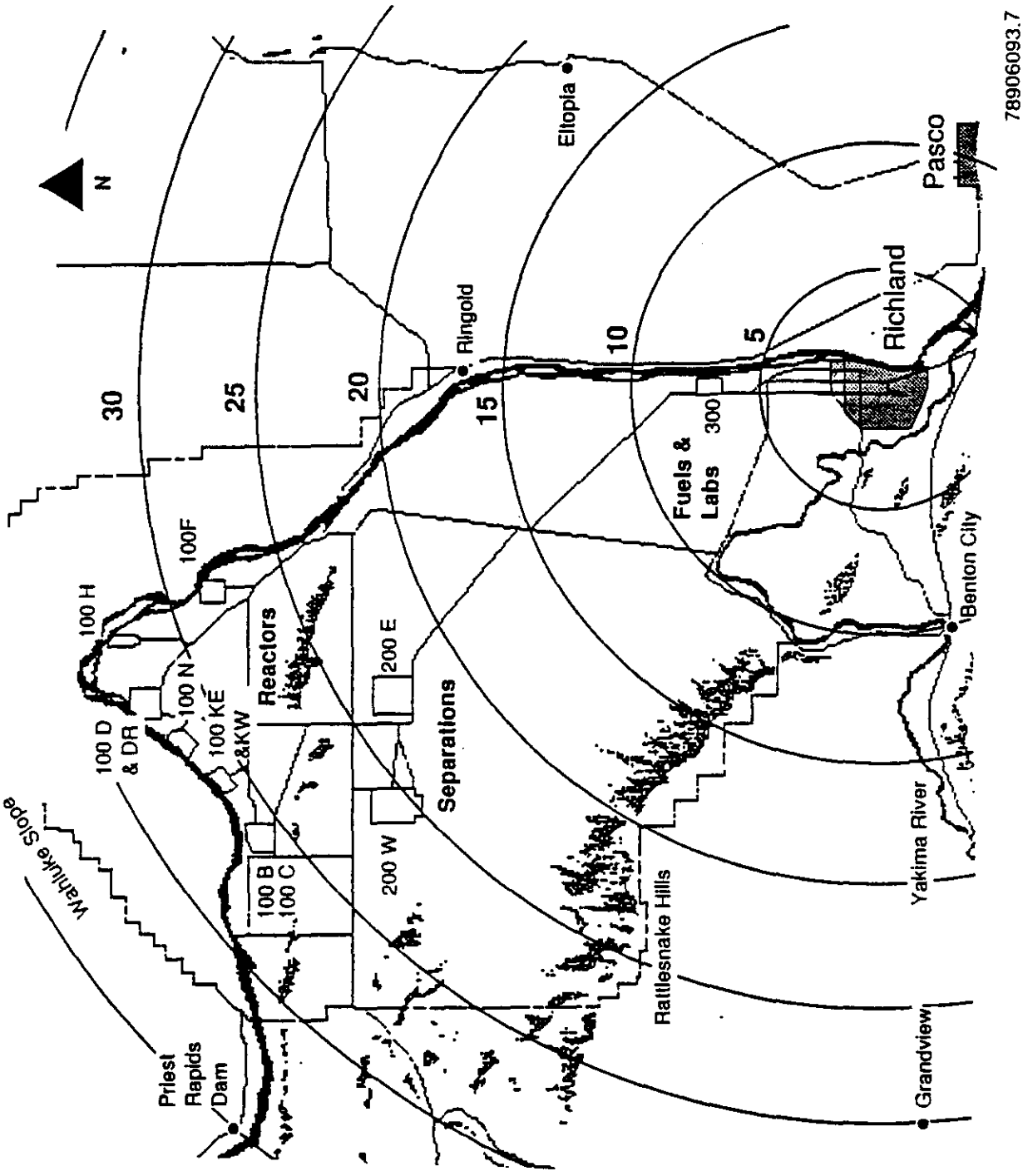
The working population of the 300 Area also varies on a daily basis; however, the estimated average is 200 to 300 people per day. Based on activity locations, the 300 Area provides the closest offsite receptor group for risk analysis. Concentrations at the river bank and offsite are expected to be insignificant and would not pose a health hazard.

2.1 100 AREA DESCRIPTION AND HISTORY

The 100 Areas are located in the northern portion of the Hanford Site, along the southern shoreline of the Columbia River. The 100 Areas are approximately 26 to 30 mi (41.8 to 48.3 km) north-northwest by northwest of the city of Richland (DOE 1987).

Between 1943 and 1963, nine water-cooled, graphite-moderated plutonium production reactors were built along the Columbia River upstream from the now abandoned town of Hanford. These reactors (100-B, 100-C, 100-D, 100-DR, 100-F, 100-H, 100-KE, 100-KW and 100-N) have been retired from service and are under evaluation for decommissioning. Construction and operation dates, facility purpose, and year of shutdown for each reactor building is provided in Taylor 1991. Figure 1 provides the location of each of the nine reactor buildings along the Columbia River.

Figure 1. Hanford Site Plant Layout.



Facilities were constructed to dispose of liquid wastes generated from fuel failures, decontamination facilities, and liquid and sludge from the irradiated fuel storage basins. These facilities (cribs and trenches) are described and characterized, including radiological inventories, in Dorian and Richards (1978).

2.7 300 AREA DESCRIPTION AND HISTORY

The 300 Area is located in the southeast portion of the Hanford Site, approximately 1.6 km (1 mi) north of the city of Richland in Benton County (Figure 2).

The 300 Areas were involved in the processing of uranium into fuel assemblies for use in the 100 Area reactors. The process involved heating and extruding the uranium into specific sizes and encapsulating the uranium fuel within an outer shell of metal alloy. The liquid by-products were discharged into the trench and pond within the 300-FF-1 operable unit (Figure 3).

Liquids and particulates in solutions disposed in the 300 Area process ponds and trenches over the years included all metallic and chemical components of the fuel fabrication process, and all separations process chemicals and solutions (particularly uranyl nitrate hexahydrate) used in the 3706 Building and the 321 Building tests of the bismuth phosphate, reduction oxidation, metal recovery, Plutonium-Uranium Reduction Extraction, and RECUPLEX processes. Chemicals used in bioassay and environmental sample analyses also contributed a much smaller portion of the 300 Area process wastes (Gerber 1992).

2.8 PURPOSE

The purpose of the soil physical separation treatability program is to evaluate methods and equipment that could be used to reduce the volume of contaminated soil required to be transferred to a waste repository. This activity will demonstrate the applicability and effectiveness of commercially available soil physical separations equipment that use water as the washing medium. Additives may be introduced to the water to enhance the effectiveness of the cleaning process. The information and experience gained may be used at other waste sites at the Hanford Site in support of the proposed macroremediation program.

2.9 SCOPE

The scope of the treatability program is limited to soil separation activities and separation equipment using water and additives for the extraction of hazardous substances and onsite storage of the contaminated material. The 300 Area material to be used in the treatability program will be soil from the inlet area of the North Process Pond and soil stored in the north end of the West Process Trench. The location of the activity is in and adjacent to the southwest corner of the process pond and east of the process trench. The 100 Area material used in this activity will consist of soils from the cribs and trenches described in Dorian and Richards (1978).

Figure 2. Hanford Site.

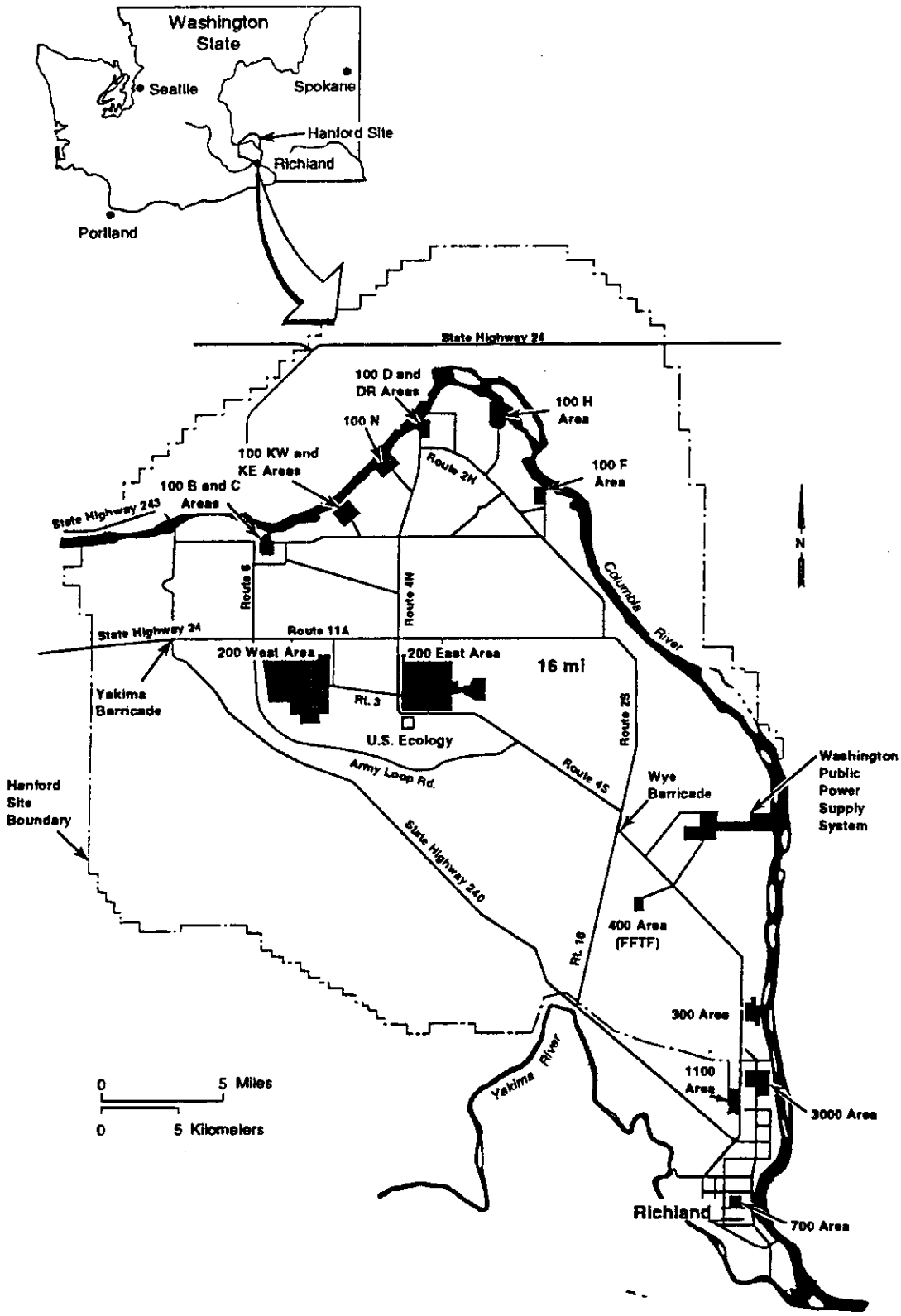
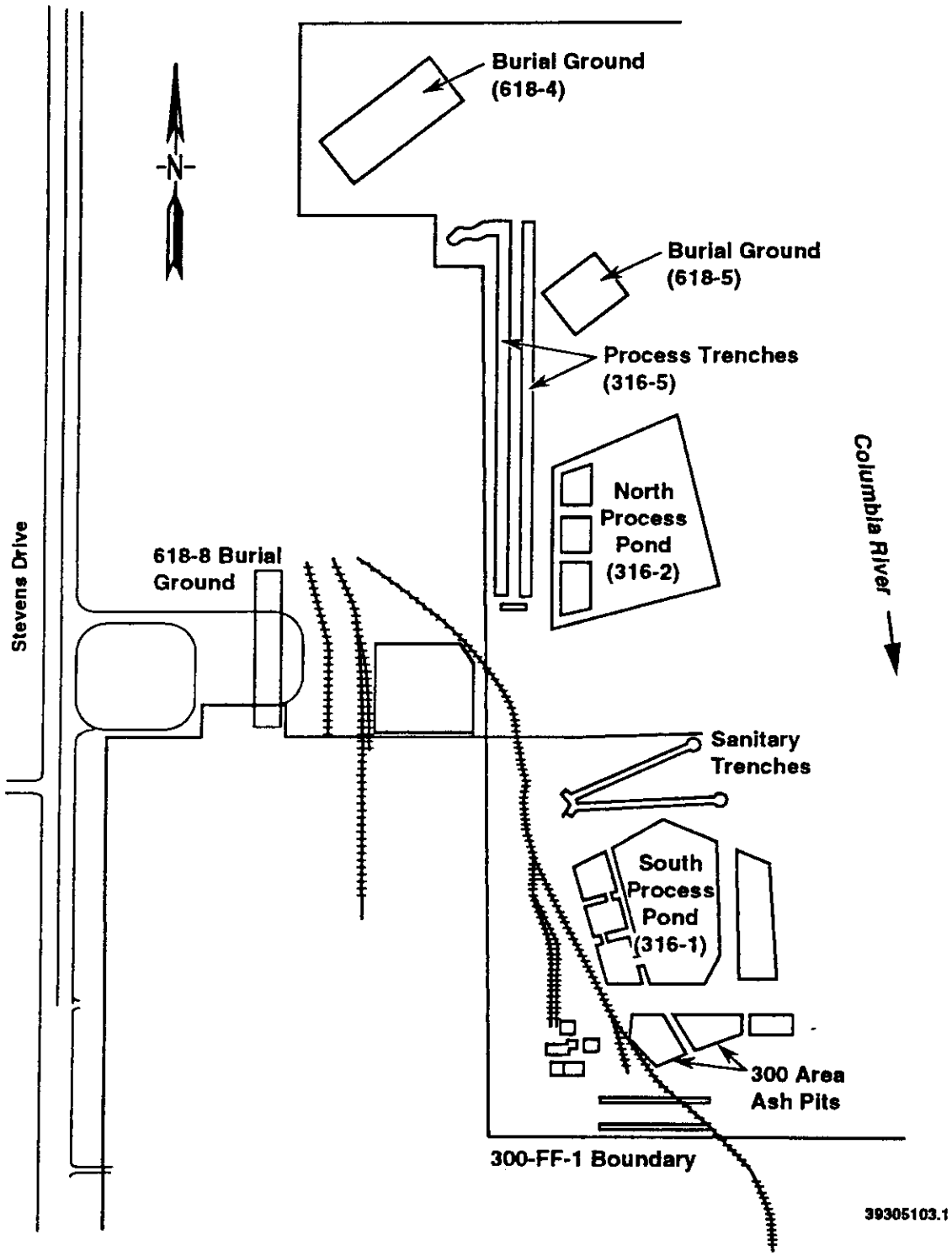


Figure 3. Layout of the 300-FF-1 Operable Unit.



The clean gravel, rock, and sand will be returned to the excavation site. The hazardous material particulates will be collected and stored onsite for an undetermined length of time in conformance with the requirements specified by regulatory agencies until a disposal plan is developed and implemented.

2.10 PROCESS DESCRIPTION

Soil physical separation processes have been used for many years in the mineral processing industry for removing materials by washing and concentrating a desired particle size or mineral. The soil separation system analyzed in this assessment has the potential to reduce the volume of contaminated material by 80% to 90%. Typical separation equipment consists of a wet grizzly feeder that will separate rocks and other large debris and remove contaminants by washing. A sketch of a typical placer system is shown in Figure 4. A detailed description of the process and equipment is provided in Field and Henckel (1991).

Soil and rock material will be stabilized to reduce fugitive dust emission and removed from the trench and process pond (located about 4.6 m [15 ft] below grade) using front-end loaders or similar equipment. The material will then be transported to the nearby equipment site and loaded onto a conveyer belt system where it will be entered into the soil physical treatment equipment and washed with water and chemical extractants to partition radioactive and hazardous chemical constituents from the sand and gravel. The chemical extractants will be nonhazardous and environmentally acceptable. The gravel and coarse sand will be separated from fine sand, silt, and heavy metals in the soil using classification equipment to segregate fine particles. Following dewatering, the clean gravel, rock, and sand will be returned to the excavation site. Dewatered soil is estimated to retain a moisture content of approximately 20%. This retained moisture content will eliminate any dust generation during transport back to the storage site in the process pond or trench.

Most hazardous material is expected to be particles or attached to particles smaller than 106 μm. Particles of this size are expected to be removed in the water wash stream and will settle out in the containment units. There are three primary options for disposing of contaminated particles. The first option is to containerize material in drums or boxes and immediately transport to a waste repository in the 200 Areas or store onsite temporarily and then ship to a waste repository. The second option is to return the contaminated material to the source locations in the process pond or trench where it will be permanently stabilized or covered with the clean soil material. The third option is to store the contaminated material for an undetermined length of time in the containment units to allow sampling and analysis of the material. A permanent disposal plan for the contaminated solids and effluent water will be developed and implemented following the sampling and analysis.

Effluent water from the separation process will be recycled and stored in containment units for sampling and analysis. The water will be evaporated or disposed of in accordance with applicable WHC and DOE requirements.

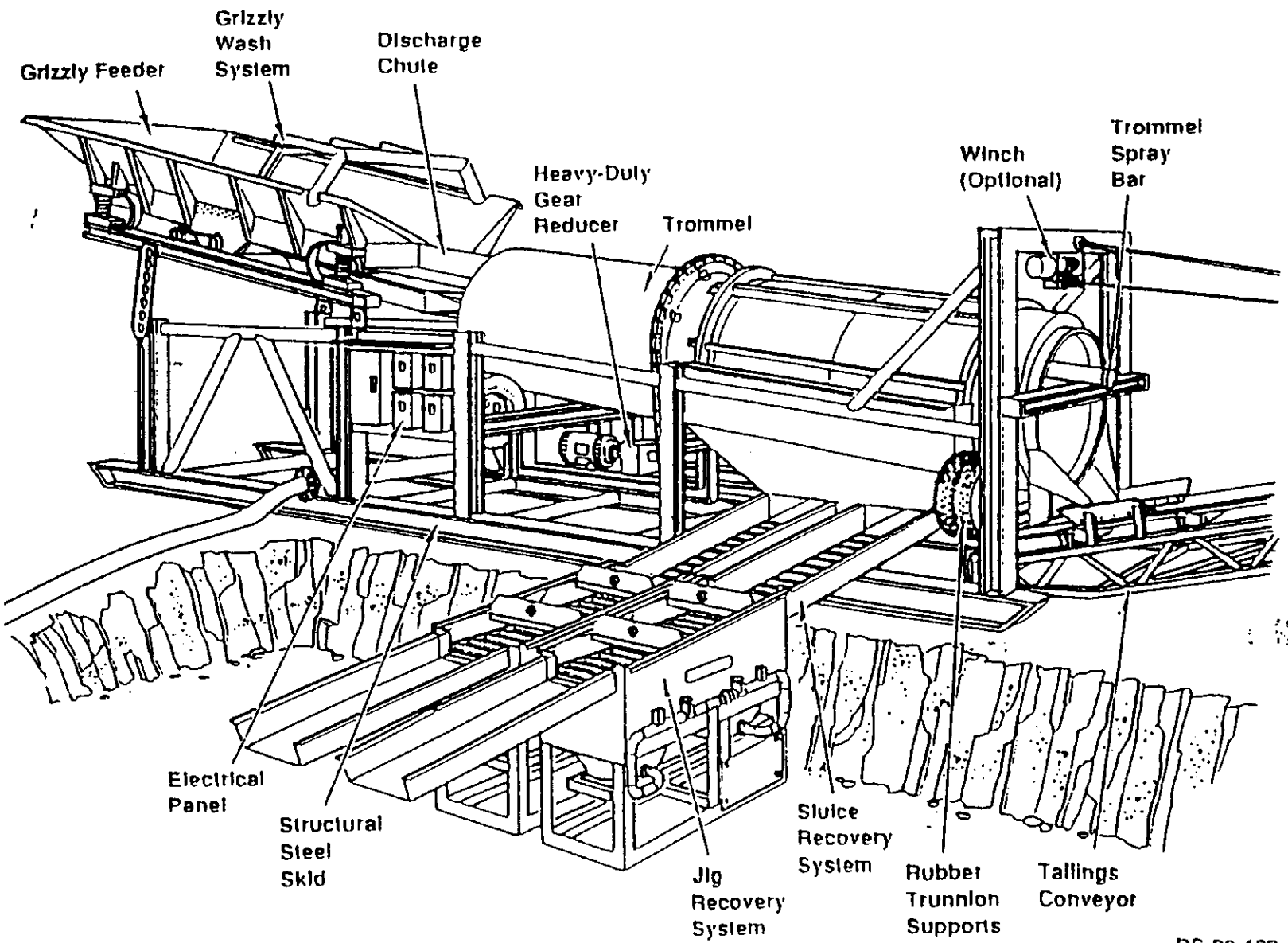


Figure 4. Typical Placer System.

Environmental Engineering management has taken action to identify disposal requirements before readiness reviews. Particulates will be removed from the effluent water and will be either containerized or returned to the source location as described above. An OSL (Section 4.0) is provided to assure the integrity of the containment unit and confinement of the stored contaminated solids and liquid. Attachment D provides a description of the closed loop water treatment system. Additional filtration may be added at a later date to remove contaminants to below regulatory concern (i.e., ion exchange). If added to the system, further safety analysis is required.

The 300 Area soil physical treatment equipment will be located in or adjacent to the southwest corner of the north process pond and adjacent to the east side of the process trench. The 100 Area soil treatment equipment will be located adjacent to the crib or trench. The equipment locations are near the contaminated soil inventories to be used in the activity. Short travel distance between the source material location and the soil separation equipment will minimize the potential for fugitive dust generation. Two OSLs are provided that require (1) soil material be stabilized to reduce fugitive dust emissions from the separation activities; and (2) appropriate action be taken to minimize the potential for environmental release of contaminated soil and effluent liquid during onsite storage.

The initial activity location at the North Process Pond (300 Area) is about 275 m (900 ft) west of the Columbia River. The distance from the process trench activity site is about 330 m (1,080 ft) to the river. The initial activity location for the 100 Area is located approximately 61 m (200 ft) southwest of the 105-F Reactor Building at the 116-F-4 Pluto crib.

These activities are expected to be performed during June through December 1993. The actual work time that equipment will be operating at the process pond will not exceed 15 working days. Three demonstration runs are planned; the two runs at the process pond will each process 150 to 300 tons of soil. The processing rates for the first and second runs will not exceed 10 and 20 tons/h, respectively. A third demonstration activity may be done at the north end of the west process trench and will involve about 7,000 tons of soil material. The processing rate for the third activity will not exceed 20 tons/h. The equipment operating period is expected to extend over several weeks at the process trench location. If a change in the siting requirements for the 300 Area activities occurs, a reevaluation of potential encroachment issues shall be performed. The 100 Area sites (independently) are not expected to process the volume described in the 300 Area activity; however, if the process proves viable, the total volume of the 100 Areas will exceed the volumes estimated for the 300 Area activity.

2.11 HAZARDS INVENTORY

The basis for the hazardous material inventory used for this assessment is soil material that was removed during the expedited response action for the 300 Area process trenches completed in 1991. The trench inventory is provided in Zimmerman and Kossik (1987). The contaminant inventory in the soil was derived by taking the highest average concentration value of samples from any 33 m (100 ft) segment of either process trench. In addition, inventories from the 100 Area liquid disposal sites were evaluated. The inventory of the 116-C-2-2 Pluto Crib was considered to be the bounding source term for this assessment. The exception to inventory consideration in the 100 Areas is the

116-N-1 site (1301-N crib and trench). This conservative bounding inventory for the two locations considered in this assessment was chosen because it represents the largest potential hazardous material inventory based on the results of characterization sampling in the process pond and trenches (Dennison et al. 1989; Dorian and Richards 1978). The metal contaminant inventory in the trenches is shown in Table 1. During removal from the trench to the soil physical separation equipment, mixing will occur between the clean and contaminated soil material by the action of the earth-removal equipment. This process will lower the concentration of the contaminant source materials. Any potential source term resulting from the material in the process trench is expected to be reduced further because of the dilution by the clean soil cover.

The hazardous material concentrations and inventory described above for the process trenches are greater than the hazardous material concentrations and inventory in the process pond or process pond inlet. To facilitate the application of this safety assessment, the process trench inventory is used as the basis for calculations done for the process pond analysis. This conservative hazardous material inventory is the basis for facility hazard classification. This inventory also provides the basis for the source term used to calculate potential hazardous chemical exposure to the uninvolved onsite worker and the nearest member of the public.

The soil physical separation process is expected to separate the hazardous materials inventory from the uncontaminated soil material. The hazardous inventory is expected to be (or be attached to) fine particles less than 106 μm in diameter. The concentrations provided in Tables 2, 3, and 4 are typical of what could be found in the separated soil fines as these samples were enriched in fines by screening before analysis (Zimmerman and Kossik 1987).

Table 1. Estimated Total Amount of Metal Contaminants in the Process Trench Sediment.

Constituent	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Uranium
Shallow sediments (kg)	3	341	2,261	108	12.8	578	54	720

Source: Zimmerman and Kossik (1987).

Uranium was the only significant radiological element found in the sediment analysis for the 300 Area. Trace concentrations of ^{60}Co, ^{137}Cs, and ^{65}Zn were found in the process trench weir box sediments. Several nonradiological hazardous materials were also detected and significant concentrations of chromium, copper, nickel, and uranium were reported (Zimmerman and Kossik 1987). The 100 Areas liquid disposal sites have received a significant amount of aqueous waste from reactor operations in the past; isotopes of interest include ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{60}Co, ^{137}Cs, ^{90}Sr, and ^{63}Ni. Based on historical data for the 100 Areas, nonradioactive wastes introduced into the soils include sodium dichromate, sodium oxalate, sodium sulfamate, sulfuric acid, bauxite, lubricating oil, gasoline, and oil contaminated with polychlorinated biphenyls (Taylor 1991). Because the contaminants have been in the soil for several years, the assumption is that soluble materials have leached from the soil material to be processed. The remaining contaminants are solids or are firmly attached to soil particles.

Table 2. Potentially Contaminated Soil Column for 116-C-2-2 Pluto Crib Sand Filter.

Radionuclide	Average pCi/g	Curies
^{238}Pu	1.9×10^{1}	1.2×10^{-1}
$^{239/240}Pu$	1.9×10^{1}	1.2×10^{-1}
^{90}Sr	3.6×10^{2}	2.2
^{3}H	7.3×10^{1}	4.5×10^{-1}
^{152}Eu	1.3×10^{3}	7.9
^{60}Co	3.7×10^{4}	230
^{154}Eu	1.0×10^{2}	6.1×10^{-1}
^{134}Cs	6.5×10^{1}	3.9×10^{-1}
^{137}Cs	1.7×10^{3}	10
^{155}Eu	1.1×10^{3}	6.7
		Total curies = 260

Source: Dorian and Richards (1978).

While there were several additional organic and inorganic nonradioactive materials detected above background levels, each were in trace amounts or very low concentrations that are very small fractions of the time weighted average (TWA), the immediately dangerous to life and health (IDLH), or the lower explosive limit values and are not expected to result in detectable airborne concentrations. Because of the small amount of these materials, they are not included in the inventory considered in this assessment.

The TWA is defined as the time weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect (ACGIH 1990).

The IDLH is the maximum concentration of a substance in air from which an unprotected worker could escape within 30 minutes without experiencing escape-impairing or irreversible health effects (NIOSH 1990). The IDLH is considered a maximum concentration above which only a highly reliable breathing apparatus providing maximum worker protection is permitted.

The following is a list of potential hazards to facility workers:

- Breathing of contaminated particulates
- Noise
- Moving equipment
- Electrical shock
- Electrical generator fire
- Radiological issues
- Spills
- Wind dispersion.

This hazards analysis focuses on the potential consequences relating to releases of contaminated particulates.

2.12 RELEASE SCENARIOS INVOLVING NATURAL PHENOMENA

Natural phenomena events such as tornadoes, floods, seismic events, and lightning would not have significant adverse effects that would increase the hazards associated with soil washing activities. Statistics and probability scopes for these events at the Hanford Site are provided in Lehrschall (1992).

High wind speeds up to 169 km/h (112 mi/h) have been determined to be a credible occurrence at the Hanford Site (>10 x 10^{-6}/yr) (Kennedy et al. 1990). Normal wind speeds of 4.8 km/h (3.0 mi/h) were found not to have an effect. An analysis at the BX-102 site involving a fractional release of the highest concentrations of radionuclides from three drive barrels exposed to a 24 km/h (15 mi/h) wind for 1 hour and 8 hours found the consequences to the uninvolved onsite worker and public to be insignificant (Lehrschall 1992). Soil washing activities would be expected to encounter much lower concentrations of radionuclides in the nCi to pCi per gram range compared to the uCi/g concentrations at the BX-102 site. The 24 km/h (15 mi/h) wind speed is the maximum wind speed under which outdoor work activities are allowed. Missiles generated by high winds could penetrate the interim storage drums that could lead to surface spills or airborne releases. The consequences associated with high winds/missiles would be bounded by the maximum release event.

The extent that contaminated particulates are suspended into the air by wind erosion is a function of the physical forces acting upon the particle. Typically, dust particles are less than 1 um to 50 um in size; particles larger than 10 um are not respirable. Particles above 50 um in size are subject to saltation and are not suspended for extended periods of time. Movement of particulates depends on the size of the particle, speed of the airstream, gravitational forces, and air viscosity (GPO 1968). Movement of particulates also depends on soil properties, such as adhesiveness and cohesiveness. Moisture acts as an adhesive and holds particles together. With sufficient moisture, no wind erosion will occur.

Surface roughness and the presence of vegetation or irregularities such as rocks on the surface also tend to suppress wind erosion. Air turbulence is also important as it is much more effective than steady velocity air in resuspending dust.

Below the threshold velocity of approximately 20 km/h (13 mi/h), no wind erosion release occurs. This analysis conservatively uses the highest resuspension rates that have been measured at the Hanford Site 3.5 x 10^{-6}/s (Sehmel 1980) as the basis for source term estimation. Higher resuspension rates are possible at the high wind velocities that exist during dust storms, but the dilution effect also increases with wind velocity as X/Q gets smaller with increasing wind speed. Thus, the effect of very high wind speeds on downwind contaminant concentrations is complicated. Ambient air dust loadings as high as 2,724 ug/m^3 have been reported for dust storms in the Tri-City area.

Particulates retained in the lungs are expected to be less than 0.5 um in size; this particle size will account for almost 50 percent of all particulates retained. The size range of particles larger than 0.5 um will be from 0.5 to 50 um. Normally, particles larger than 50 um are prevented from reaching the lung by nasal hair and flow paths. The following are examples of typical particle sizes: clay 0.1-2.0 um; silt 2.0-20.0 um; fine sand 20.0-

120.0 um; and coarse sand 120.0 um to .2 mm. (The Industrial Environment - its Evaluation and Control, U.S. Department of Health Education and Welfare 1973)

3.0 HAZARD ASSESSMENT

3.1 INTRODUCTION

The soil physical treatment activities considered in this assessment will be performed (1) in and near the southwest corner of the North Pond; (2) the north end of the West Process Trench in the 300 Area; and (3) in the 100 Area liquid disposal sites. The process will employ soil separation equipment using water and additives to enhance the cleaning effectiveness. The additives to be used will be nonhazardous and environmentally acceptable.

Different energy sources were considered that could cause a hazard inventory to become a source term. Mechanical energy of process equipment, equipment fuel fires, range fires, and wind are considered the most probable initiators of a source term. For purposes of this assessment, wind combined with mechanical action are the initiators used for the generation of a source term as wind is common to all the activities of this test while the other initiators considered were not. Further, a combination of wind, dry soil material, and mechanical action would result in the receptor groups receiving the largest credible exposure to hazardous materials. Other naturally occurring energy sources were considered in this assessment. Because the worst case has been assumed, natural phenomena events would not adversely affect the conclusions in this assessment. The effects of these events on the inventory would be minimal because the dispersion from other inventories resulting from these forces would be greater than the inventory of the activity assessed. Lightning would not cause a source term greater than that assessed if lightning were to strike the rubber-tired transport vehicle.

Nuclear criticality is considered incredible because of the small amount and type of uranium in the soil material in the pond and trench (Appendix A). The average uranium enrichment in the trenches was determined to be less than 1.0 wt% ^{235}U and all sampling indicates a homogeneous distribution of uranium in the matrix (Appendix A; Zimmerman and Kossik 1987). The amount of all forms of uranium in the process pond was also below the nuclear criticality minimum level (Dennison et al. 1989). The average plutonium concentration per gram of soil in the 116-C-2-2 crib is approximately 3.9×10^{-11} Ci or 39.0 pCi/g that is below the limit for distribution within a matrix specified in WHC-CM-1-6, *Radiological Control Manual* for gross alpha. The plutonium concentration is also below the 1.9×10^{2} pCi/g as specified in WHC-CM-7-5, *Environmental Compliance* for unrestricted access. This concentration is approximately 39.0 uCi/ton of soil. The major dose contributor for the 116-C-2-2 crib would be ^{60}Co. An estimate on the total curie content for the 116-C-2-2 crib was made in a study by Dorian and Richards (1978). If 230 Ci of ^{60}Co were decayed from 1978 to 1993 and ^{60}Co has a half life of 5.271 years, then 28.75 Ci is assumed to remain in the crib. This estimate would produce 4.71×10^{3} pCi/g of Co^{60} in the soil column. Assuming the total mass for the crib was approximately 7.28×10^{4} tons of soil, an estimate of 395 Uci/ton would be appropriate.

The radiological and toxicological dose consequences determined by the analysis were found to be consistent with a low hazard nuclear activity (WHC-CM-4-46; Schade 1990). Hazard classification provides the basis for the

level of DOE and WHC review and approval of safety documents based on the postulated hazard within a facility or encountered by an activity.

3.2 ASSESSMENT

This assessment considers the contaminant concentrations at the source location, as the soil moves through the washing process, and the movement of the clean and contaminated material to permanent storage. The output from the soil separation process will be less than 10% to 20% fine sand and the remainder would be gravel and coarse sand. The contaminants are expected to be fine particulates or attached to fine particles. The gravel and coarse sand is expected to contain minimal residual hazardous material.

Removal of the contaminated fine material from the containment unit is planned to be done while the material is in a stable condition. The contaminated fine material will either be containerized for shipment to a waste site repository on the Hanford Site or returned to the source locations in the pond or trench where the material will be stabilized. If the fines were to become dry without stabilization protection, they would represent a potential source term.

For purposes of this assessment, the source term is created during transport of the fine materials from the containment unit to the source material pit in the trench or pond. Transportation equipment involved is a 9.1 m^3 (10 yd^3) capacity dump truck. It is assumed that the truck bed area is 9 m^2 (97 ft^2), the soil material is dry, and the truck is located at ground level.

The following is a description of the scenario leading to the generation of the source term. The stabilized contaminated fine soil material is removed from the containment unit by a front-end loader and is loaded into a dump truck for transport to the processing location. The top of the sides of the truck bed are 2.4 m (8 ft) from ground level and the truck is filled to capacity. The contaminated soil material in the truck is allowed to become dry. The wind is from the east at 21 km/h (13 mi/h). The truck remains at ground level while moving to the east a distance of 402 m (0.25 mile) at 24 km/h (15 mi/h) before descending into the bottom of the trench 4.6 m (15 ft) below ground level. The trip duration is 60 seconds. A source term is generated by wind blowing across the surface of the dry, contaminated soil in the truck bed. Fugitive dusts containing radioactive nuclides are then carried downwind, creating a maximum concentration at 100 m (328 ft) of 1.92 x 10^{-5} mg/m^3 of ^{60}Co by volume at ground level (Appendix B). This concentration is well below regulatory limits for ^{60}Co to the receptor groups - the facility worker, the uninvolved onsite worker, and the public who are assumed to be on the west bank of the Columbia River.

Calculations were done to estimate the dose rate for the dump truck. By assuming homogenous mixture for the crib and the major dose contributor to be ^{60}Co, dose rates were estimated using Micro-Shield[1] software. The entire inventory of the crib was assumed to be mixed within the dump truck bed. The

[1]Micro-Shield is a registered trademark of Grove Engineering Inc., Rockville, Maryland.

results of the Micro-Shield calculation of total activity in the truck are provided in Table 3.

Because the second assumption is not credible, and the volume of the dump truck is a fraction of the total volume of the crib, the dose rate for the dump truck should be proportionally lower. Therefore, the dose rate for the activity will be the lower number (Table 3).

Table 3. Exposure Rates from the 116-C-2-2 Contaminated Sand Filter.

Distance	Contact	.3 m (1 ft)	.6 m (2 ft)	.9 m (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)	1.8 m (6 ft)
Dose rates (mr/h)	2,811 8.97	1,997 6.38	1,299 4.14	904 2.88	661 2.1	520 1.66	392 1.25

The soil washing process will presumably concentrate the contaminates of concern as material is processed through the system. Conservative estimates have postulated an increase by a factor of 10. For example, for a container that is the same size as the carrier, a contact dose rate will increase to approximately 90 mr/hr. Smaller containers will have proportionally lower dose rates. This dose rate is still within the criteria for a low hazard operation. For disposal of contaminated soils, the concentrated residue will be containerized and therefore not subject to wind erosion as the preprocessed soils. An accident scenario can be hypothesized for a burial box or drum rupture of processed material, but the source term will be smaller than that which was analyzed.

Potential concentrations of other hazardous materials are also well below regulatory limits as is the potential radiological insult to the three receptor groups. The receptor groups include the facility worker (the worker directly involved in the activity); the uninvolved site worker (the Hanford Site worker located 100 m (330 ft) from the activity or beyond); and the general public, who are located offsite. The conservative inventory and resulting concentrations identified in Tables 2 and 3 result in very low potential exposures to facility workers and uninvolved onsite personnel.

Based upon activity locations, the 300 Area provides the closest offsite receptor group for risk analysis. Although the 300 Area does not contain the inventories normally associated with 100 Area liquid disposal sites, those radionuclide inventories were included as a conservative estimate for risk analysis. The west bank of the Columbia River is located about 275 m (900 ft) and 330 m (1,080 ft) from the work locations at the process pond and the process trench, respectively. Concentrations at the river bank and offsite are expected to be insignificant and would not pose a health hazard.

There was no credible hazard inventory or event identified during the assessment of the hazards of this activity that could result in a detectable offsite exposure.

A summary of the hazard threshold values used in this assessment and estimated soil concentrations of hazardous materials in soils transported by the dump truck are provided in Table 6. These values are used to determine the level of rigor analysis. A source term is estimated from the surface

area of the load using the resuspension rate of 3.5 x 10^{-6}/s, the highest rate postulated for the Hanford Site (Sehmel 1980). The downwind concentration was estimated using Emergency Prediction Information[2] software; details of those calculations are provided in Appendix B. Table 4 provides a summary of maximum radionuclide concentrations expected from both the 100 and 300 areas. Table 5 provides the toxicological inventory and resulting airborne concentrations at 100 m (330 ft).

Table 4. Radionuclide Concentrations.

Constituent	Soil concentration (pCi/g)
Alpha	8, 870
Beta	42,000

Table 5. Toxicological Inventory and Resulting Concentrations Based on the Source Term Scenario.

Substance	Soil concentration[(a)] (ug/g)	Soil background (ug/g)	Maximum ground level concentration in air at 100 m (330 ft) (mg/m^3)	Exposure limits	
				TWA (in mg/m^3)	IDLH
Silver	362	<1	1.6×10^{-4}	0.01	n/e
Chromium^{+6} (b)	604	6-10	2.7×10^{-4}	0.05	30
Copper	95,300	8-22	4.2×10^{-2}	1.0	n/e
Nickel[(b)]	1,750	5-9	7.7×10^{-4}	0.1	n/e
Uranium	9,370	0.6-8	4.1×10^{-2}	0.2	20

NOTES: [(a)]Credible calculated values.
[(b)]Carcinogen.
n/e = none established.

Table 6. Hazard Threshold Values.

Hazard category	Facility worker	Onsite	Offsite
General use	--	--	--
Radiological	<Exempt quantity	--	--
Chemical	none listed	<0.1 IDLH	<0.01 IDLH
Low hazard	--	--	--
Radiological	≥Exempt quantity <25 rem	≥0.1 rem <5.0 rem	≥0.01 rem <0.5 rem
Chemical	none listed	≥0.1 IDLH	≥0.01 IDLH

Source: Schade (1990).

[2]Emergency Prediction Information is a registered trademark of Homann Associates, Inc., Fremont, California.

3.3 SUMMARY AND CONCLUSIONS

The radiological and toxicological dose consequences were found to be consistent with the low hazard classification defined in WHC-CM-4-46. The basis for the radiological and toxicological determinations leading to the low hazard classification were conservatively taken from the results of sampling in the 300 Area Process Trenches (Zimmerman and Kossik 1987; Taylor 1991). Credit was taken in this assessment for radioactive decay since sampling. Potential direct exposure dose rate from radiation would be approximately .010 rem/hr. This is a conservative estimate of direct dosage to the involved facility worker. The source term from a postulated release resulted in very low to insignificant toxicological and radiological exposures to the three receptor groups of concern and would be well below regulatory limits. The closest offsite receptor group would be located on the west bank of the Columbia River or approximately 275 m (900 ft) and 330 m (1,080 ft) from the work locations at the process pond and the process trench, respectively.

Therefore, using the most conservative model available, the air concentration at 100 m (330 ft) for the most limiting isotope within the crib would not reach a level requiring public concern (derived concentration guide). Consequently, the exposure to the onsite worker, uninvolved onsite worker, and the public receptor would be well below the risk acceptance limits as defined in WHC-CM-4-46.

The nuclide of concern for the 100 Areas is normally ^{90}Sr; however, the nuclide of concern for the 116-C-2-2 disposal site is ^{60}Co. Therefore, a comparison can be made between ^{60}Co and ^{90}Sr. The derived air concentration (DAC) for both radionuclides are within an order of magnitude for lung retention class (DOE 1988). Additionally, the maximum permissible body burden for both nuclides is within 1 order of magnitude (GPO 1970). The derived concentration guides for radionuclides in WHC-CM-7-5 show the values for ^{60}Co and ^{90}Sr to be separated by approximately 1 order of magnitude. If these types of soil washing activities occur at other liquid waste disposal sites, it would be prudent to revaluate the potential airborne consequences for each particular inventory.

Normal jobsite worker safety requirements contained in the HWOP, JSA, and RWP will provide adequate protection for the facility worker and the uninvolved onsite worker. Committed mitigation efforts are anticipated to ensure ambient air for the facility worker does not require respiratory protection. Normal health physics requirements require air sampling to verify the existence or absence of airborne contaminants in the work environment. Radiological and industrial hygiene practices will provide protection to the three receptor groups of concern during off-normal circumstances.

There is no indication that a credible scenario can be postulated to provide a fire event. The lack of combustible material precludes any further study in this area. An electrical fire is possible; however, the fire would be enveloped by the postulated dispersion of contaminated soils by wind.

4.0 LIMITS AND PRUDENT ACTIONS

An OSL is an auditable limit established within WHC for the safe operation of a nonreactor nuclear facility or activity. The U.S. Department of Energy Richland Operations Office has a policy that at least one acceptable limit be established to assure the facility or activity is operated safely and within the bounds of the safety assessment. Two OSLs have been established to assure the validity of this safety assessment and to minimize exposure and environmental impact to ALARA. These OSLs require (1) that the potential for fugitive dust be minimized and (2) that contaminated soil and effluent liquid be stored onsite and disposed of in accordance with regulatory requirements.

4.1 OPERATIONAL SAFETY LIMITS

Operational Safety Limit - 1

This OSL applies to minimizing the potential for radioactive contaminated fugitive dust generation.

1.0	TITLE:	Mitigation of Fugitive Dust.
1.1	APPLICABILITY:	This requirement is applicable to the mechanized soil handling and storage activities (excavation, hauling, and stock piling activities).
1.2	OBJECTIVE:	To reduce the potential for fugitive dust generation from soils accumulated during mechanized soil sampling activities.
1.4	REQUIREMENT:	Soils accumulated at the work site as a result of mechanized soil washing activities, shall be stabilized (i.e., water, fixants, and tarps) if wind speeds exceed 15 km/h (10 mi/h) or if spoils are left unattended (off shift).
1.5	SURVEILLANCE:	During operation and at the end of the shift, the responsible operating organization shall visually verify that the soil spoils are stabilized. This verification shall be documented in the field log at the end of the shift by the field team leader or the site safety officer.

1.6 RECOVERY:

1.6.1 Noncompliance with the requirement:

1. Once a determination has been made that the operating organization is not in compliance with the requirements of this OSL, operations shall immediately cease. The approval of Safety Assurance will be required for restart of operations.

2. Failure to stabilize the soil spoils shall require the responsible operating organization to stabilize the

spoils and provide verification before restart of operations. Concurrence by independent safety and line management shall also be required before restart.

3. The OSL violation shall be documented as an unusual occurrence report.

1.6.2 Noncompliance with the surveillance:

1. The surveillance shall be performed immediately.

2. If surveillance determines noncompliance with the requirement, then recovery actions in Section 1.6.1 of this OSL shall be initiated.

3. Failure to implement a surveillance requirement shall be documented as an off-normal occurrence.

1.7 AUDIT POINT: The field log shall be audited weekly to verify compliance with the requirements and surveillance. The results of the audit shall be documented in the field log.

1.8 BASIS: The basis for this requirement is to assure soil spoils subjected to winds speeds greater than 15 km/h (10 mi/h) (18 km/h [12 mi/h] wind speed required for soil particles small enough to be resuspended) or if spoils are left unattended will not result in resuspension of any radioactive contaminants. This limit is applicable to soils excavated from trenches, pits, solid waste disposal sites, or other areas.

Operational Safety Limit - 2

This OSL applies to storage of contaminated soils and effluent liquids from soil washing activities.

2.0 TITLE: Onsite Storage of Contaminated Soil and Effluent Liquid.

2.1 APPLICABILITY: This limit applies to any onsite storage of soil or liquid contaminated with hazardous material associated with the evaluation of soil physical treatment equipment and methods (as described in more detail in Section 2.0 of this safety assessment).

2.2 OBJECTIVE: To minimize the potential for releasing contaminated fugitive dusts and liquids to the environment.

2.3 REQUIREMENTS: Contaminated soil and waste liquids must be stored in a manner that assure temperature and atmospheric extremes will not cause a release of contaminated material above regulatory requirements to the environment. The onsite storage of contaminated soil

and liquids must comply with applicable regulations as determined by Environmental Assurance and Independent Safety.

2.4 SURVEILLANCE: Project documents (HWOP, JSA, and RWP) will specifically require that contaminated soil and liquid material are maintained in a condition that minimizes the potential for release to the environment. Project documents will confirm that the containment of the stored soil and liquid are periodically assessed and appropriate action is taken, if necessary.

2.5 RECOVERY:

2.5.1 Noncompliance with the requirements:

If compliance with the requirements of this OSL are observed to be inadequate, prompt action will be taken to stabilize the contaminated soil and liquid material to the satisfaction of the site safety officer. The review of the deficiency will include the site field team leader, safety officer, and Independent Safety who will jointly determine additional recovery actions, if any. The OSL violation shall be documented as an unusual occurrence report.

2.5.2 Noncompliance with surveillance requirements:

If compliance with the surveillance requirements are observed to be inadequate, an assessment shall be performed immediately. If noncompliance is determined, then recovery actions in Section 2.5.1 of this OSL shall be initiated. Failure to implement surveillance requirements shall be documented as an off-normal occurrence.

2.6 AUDIT POINT: An audible field logbook shall be maintained at the site documenting the results of the surveillance. This log shall be reviewed weekly by the operating organization assuring compliance with the OSL requirements and surveillance. Other audit points are project documents and Environmental Engineering surveillances.

2.7 BASIS: The release of contaminated soil or liquid to the environment must be minimized ALARA to reduce the potential effect to the environment, the facility workers, and people not involved in this project.

4.2 PRUDENT ACTIONS

Four prudent actions have been adopted by Environmental Engineering management to further assure that contamination control is maintained, potential hazards are removed, and ALARA goals are met.

Function 1 - Removal of contaminated equipment from work site.

Prudent Action 1 - Even though radioactive contamination is expected to be minimal, equipment to be removed from the activity site will be decontaminated and controlled in accordance with WHC requirements.

Function 2 - Disposal plan for stored contaminated solid fine soil and liquid material.

Prudent Action 2 - A disposal plan will be developed within three months after receiving the final analytical report of the treatability test. The plan will be implemented as necessary to remove the hazardous material risk.

Function 3 - Mitigation of dusts at the loading hopper.

Prudent Action 3 - Visual observation of hopper area may require wind screens to be constructed around the hopper area to minimize dust emissions.

Function 4 - Test operations.

Prudent Action 4 - Activity operation will be conducted in compliance with appropriate HWOP, JSA, and RWP requirements.

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APPENDIX A

CRITICALITY EVALUATION OF THE 316-5 PROCESS TRENCHES

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From: Reactor Physics and Special Studies
Phone: 6-4669 HO-38
Date: January 13, 1992
Subject: 300 AREA TRENCH ASSAY INTERPRETATION

To: W. E. Taylor B1-35

cc: D. L. Harrold B1-35
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H. Toffer HO-38
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References:

1. Memo, H. Toffer to G. L. Smith, "Criticality Evaluation of 300 Area Trench," August 1, 1991.
2. DOE/TIC-11026, "Radioactive Decay Data Tables," D. C. Kocher, ORNL, 1981.
3. UNI-489, "Nuclear Criticality Safety Analyses and Technical Bases for Shipping Reject Uranium Metal in NLO Boxes," H. Toffer, UNC, January 16, 1976.

The assay results from the 300 Area process trenches indicate uranium enrichments in U-235 in the range of 2 to 3 wt%. These results are attributed to the failure to account for the uranium isotope U-236 which has built up in the uranium fuel during preceding cycles of reactor exposure combined with reprocessing and reuse. The best estimate of the enrichment of the uranium in the process trenches is 0.988 wt% from the Reference 1 memo.

It is estimated that the amount of uranium in the trench soil is about 720 kg (Reference 1). This is less than half the safe mass of 1,500 kg for 1.25 wt% uranium enrichment in solutions (Reference 1), and cannot be made critical.

BACKGROUND AND ANALYSIS

The 300 Area trenches were put into use in March of 1975. They received mostly uranium bearing process solutions from the N Reactor fuel fabrication facility. Some limited amounts of solutions containing depleted uranium were added by the Pacific Northwest Laboratory.

The process effluent system was modified in 1987 by adding ion exchangers and filters to reduce the chemical and particulate discharge to the process trenches. As a result of the cessation of N Reactor fuels manufacturing, this system was never used.

The uranium in the weirbox was recovered in 1987. The uranium concentrations in the trench were too low for feasible recovery.

It is our understanding that the heavy material in the soil will be partitioned to reduce the volume and the costs of disposing of it.

The trenches were cleaned up in 1991 and the material assayed with the results included in Attachment 1 to this memo. The indicated activities of U-235 and U-238 were converted to concentrations as shown in Table 1 using the specific activities of the two uranium isotopes. For this analysis, it was assumed that the U-238 was equal to the total uranium. This approximation will be accurate to within about 1%.

The U-238 concentration at several locations in the trench were calculated and are recorded in Table 2 for several locations with respect to the discharge to the trench. The design of the weirbox and trench, and the turbulence of the liquid stream tended to minimize the deposition of the uranium particulates in the first 20 meters of the trench. The maximum deposition occurred at about 20 meters from the point of discharge into the trench.

DISCUSSION

The expected uranium enrichment in the 300 Area process trench is 0.988 wt% U-235, Reference 1. As shown in Table 1, the ratios predicted by the alpha counts are generally higher than this by a substantial amount. The ratios calculated from the gamma counting method tend to be in the range of 0.0108 which is also higher than expected.

The total amount of uranium in the trench is reported as 720 kg in Reference 1, while the safe mass for uranium enriched to 1.25 wt% in U-235 in solutions is reported as 1,500 kg. The average effective enrichment of the uranium in the trench is reported as 0.988 wt%, Reference 1. Thus, the safe mass would be larger. The net result is that the uranium in the trench cannot become critical even under the most conservative assumptions.

Table 1. Apparent Enrichment of Uranium in 300 Area Process Trench

Assay I. D.	Activity Type	Isotopic Activity (pCi/gm) U-235*	U-238	U-235/U-238 Atomic Ratio
B01032	Alpha	1.7	9.2	0.0291
	Gamma	69.52	0.9821	11.15**
B01033	Alpha	74.0	360.0	0.0324
	Gamma	30.79	448.0	0.0108
B01034	Alpha	320.0	2900.0	0.0174
	Gamma	219.3	3196.0	0.0108
B01035	Alpha	9.2	50.0	0.0290
	Gamma	2.074	26.4	0.0123
B01036	Alpha	140.0	1070.0	0.0206
	Gamma	84.64	1246.0	0.0107
B01038	Alpha	1600.0	6030.0	0.0418
	Gamma	638.4	9143.0	0.0110
B01040	Alpha	380.0	9130.0	0.0066
	Gamma	691.0	9659.0	0.0113
B01041	Alpha	2.1	8.6	0.0385
	Gamma	0.3918	4.33	0.0143
B01042	Alpha	7.4	33.0	0.0353
	Gamma	3.013	46.01	0.0103
B01043	Alpha	10.0	77.0	0.0205
	Gamma	8.784	129.6	0.0107
B01044	Alpha	2.9	30.0	0.0152
	Gamma	1.717	26.74	0.01011
B01045	Alpha	0.68	4.3	0.0249
	Gamma	--	--	--
B01046	Alpha	4.2	69.0	0.0096
	Gamma	3.443	53.18	0.0102

*This activity includes the U-236 activity.
**This ratio is in error, perhaps due to incorrect data transcription.

Table 2 Apparent Uranium Concentrations in 300 Area Process Trench.

Assay I. D.	Distance meters (ft)	Depth meters (ft)	Concentration (gm U-238/gm)
B01034	0.0	0.0	8.63E-03
B01033	0.0	1 (3.0)	1.07E-03
B01040	20.0 (65.6)	0.0	2.72E-02
B01036	20.0 (65.6)	1 (3.0)	3.18E-03
B01043	100.0 (328)	0.0	2.29E-04
B01042	100.0 (328)	1 (3.0)	9.82E-05
B01046	400.0 (1310)	0.0	2.05E-04
B01045	400.0 (1310)	1 (3.0)	1.28E-05

Notes:
1. The distance is measured from the point of discharge into the trench.
2. The depth is the sample depth into the trench bottom.
3. The samples have been concentrated into about 3% of the original soil volume.

The quantity of uranium in the trench reported as 720 kg (Reference 1) was from the Table 2 data.

It is noted that the sampling technique used to measure the uranium activity concentrated the uranium into about 3% of the original soil volume.

The overestimate of the U-235 concentration based on the alpha response is due to a failure to differentiate between the alpha particles from U-235 and those from U-236. Alpha particles are emitted from U-236 with three major energies in the range from 4,332 keV to 4,494 keV. The alpha particles from U-235 have energies in 14 major groups ranging from 4,150 keV to 4,598 keV. These energies are shown in Attachment 2, from the Nuclear Data Tables, Reference 2. The uranium isotope U-236 is present in very small trace amounts in recycled uranium, if at all. When uranium is irradiated, there is competition between capture and fission in U-235 which results in a buildup of U-236 in the uranium resulting from non-fission capture. The unburned uranium in the N Reactor fuel was recovered during the plutonium separation process and recycled into the N Reactor fuel. The U-236 has a shorter half-life than the U-235 so that the specific activity is greater. The half-life for U-235 is 7.04×10^8 years, while the half-life of U-236 is 2.34×10^7 years. The specific activity of each isotope is proportional to the inverse of its half-life. Thus, the U-236 is $7.04 \times 10^8 / 2.34 \times 10^7 = 30$ times as active as U-235 for the same number of grams (or atoms) of each isotope. It is calculated that for about 640 ppm of U-236 combined with 1 wt% U-235 in the uranium fuel, the activity would be equivalent to a U-235 enrichment of 2.9 wt%. This is the apparent enrichment of the uranium at the first entry in Table 1. It is noted that UNI-489, Reference 3, used a U-236 content of 0.04 wt% (= 400 ppm) and that further recycle of the N Reactor uranium would increase this U-236 content. The composition table from UNI-489 is included as Attachment 3 to this memo.

It is noted that for unirradiated uranium that is used for commercial power reactor fuel, there will be no U-236 present and the alpha spectroscopy will produce acceptable accuracy for U-235 assays.

The difference between the 1.08 wt% calculated from the gamma spectral analysis and the 0.988 wt% in Reference 1 is attributed primarily to uncertainties in the gamma spectroscopy with minor contributions from uncertainties in the Reference 1 estimates.

The uncertainty imposed in using the safe mass for 1.25 wt% uranium scrap is conservative because the average enrichment for the uranium in the trench is estimated as 0.998 wt%. There is further conservatism inherent in the safe mass calculations which assume an ideal mixture composed of fuel rods in water with an optimum diameter and spacing.

RECOMMENDATIONS

The best estimate of the enrichment of the uranium in the process trenches is 0.988 wt% from the Reference 1 memo.

The amount of the uranium in the process trenches is 720 kg, as reported in Reference 1. This is a conservative upper limit.

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Reactor Physics and Special Studies
Date

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Attachments

ATTACHMENT 1 RESULTS (page 1)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01032	1	7/30-31/91	Gross Alpha	24 ± 10	
			Gross Beta	30 ± 6	
			^{90}Sr	(2 ± 7)	E-01
			^{99}Tc	(3.8 ± 0.2)	E+00
			Total Uranium	(2.8 ± 0.6)	E+01
			^{234}U	(1.3 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.2 ± 1.0)	E+00
			^{238}Pu	(1.9 ± 1.5)	E-01
			$^{239,240}Pu$	(1.4 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(1.058 ± 0.047)	E+01
			^{60}Co	(2.202 ± 0.322)	E-01
			^{137}Cs	(5.229 ± 0.334)	E-01
			^{226}Ra	(4.213 ± 0.449)	E-01
			^{235}U	(6.952 ± 1.100)	E-01
			^{238}U	(9.821 ± 2.557)	E-01
			^{228}Th	(6.424 ± 0.287)	E-01
			^{232}Th	(5.937 ± 1.114)	E-01
B01033	2	7/30/31/91	Gross Alpha	316 ± 25	
			Gross Beta	454 ± 12	
			^{90}Sr	(1.3 ± 12)	E+00
			^{99}Tc	(9.9 ± 0.3)	E+01
			Total Uranium	(1.0 ± 0.2)	E+03
			^{234}U	(5.2 ± 0.3)	E+02
			^{235}U	(7.4 ± 0.9)	E+01
			^{238}U	(3.6 ± 0.2)	E+02
			^{238}Pu	(7 ± 6)	E-02
			$^{239,240}Pu$	(1.7 ± 0.7)	E-01
			Gamma Scan:		
			^{40}K	(9.295 ± 0.416)	E+00
			^{60}Co	(1.130 ± 0.261)	E-01
			^{137}Cs	(5.534 ± 0.426)	E-01
			^{226}Ra	(4.849 ± 0.581)	E-01
			^{235}U	(3.079 ± 0.028)	E+01
			^{238}U	(4.480 ± 0.076)	E+02
			^{228}Th	(1.533 ± 0.065)	E+00
			^{232}Th	(6.262 ± 1.175)	E-01

ATTACHMENT 1 RESULTS (page 2)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01034	3	7/30-31/91	Gross Alpha	3.12 ± 0.08	E+03
			Gross Beta	5.42 ± 0.05	E+03
			^{90}Sr	(1.5 ± 0.3)	E+01
			^{99}Tc	(7.38 ± 0.09)	E+02
			Total Uranium	(6.7 ± 1.3)	E+03
			^{234}U	(3.9 ± 0.3)	E+03
			^{235}U	(3.2 ± 1.2)	E+02
			^{238}U	(2.9 ± 0.2)	E+03
			^{238}Pu	(2.3 ± 1.4)	E-01
			$^{239,240}Pu$	(1.6 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(5.226 ± 0.629)	E+00
			^{60}Co	(5.536 ± 0.712)	E-01
			^{137}Cs	(1.083 ± 0.121)	E+00
			^{226}Ra	(1.244 ± 0.201)	E+00
			^{235}U	(2.193 ± 0.011)	E+02
			^{238}U	(3.196 ± 0.029)	E+03
			^{228}Th	(5.385 ± 0.133)	E+00
			^{232}Th	(1.429 ± 0.251)	E+00
B01035	4	7/30-31/91	Gross Alpha	49 ± 12	
			Gross Beta	66 ± 5	
			^{90}Sr	(2 ± 6)	E-01
			^{99}Tc	(2.25 ± 0.03)	E+03
			Total Uranium	(1.1 ± 0.2)	E+02
			^{234}U	(6.9 ± 0.2)	E+01
			^{235}U	(9.2 ± 1.2)	E+00
			^{238}U	(5.0 ± 0.5)	E+01
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(0 ± 5)	E-02
			Gamma Scan:		
			^{40}K	(9.417 ± 0.431	E+00
			^{60}Co	(8.216 ± 2.380)	E-02
			^{137}Cs	(3.930 ± 0.291)	E-01
			^{226}Ra	(3.934 ± 0.420)	E-01
			^{235}U	(2.074 ± 0.168)	E+00
			^{238}U	(2.646 ± 0.326)	E+01
			^{228}Th	(5.725 ± 0.272)	E-01
			^{232}Th	(5.938 ± 1.018)	E-01

ATTACHMENT 1 RESULTS (page 3)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01036	5	7/30-31/91	Gross Alpha	1.62 ± 0.06	E+03
			Gross Beta	1.79 ± 0.03	E+03
			^{90}Sr	(6.7 ± 3.6)	E+00
			^{99}Tc	(6.91 ± 0.07)	E+02
			Total Uranium	(2.1 ± 0.4)	E+03
			^{234}U	(1.53 ± 0.08)	E+03
			^{235}U	(1.4 ± 0.3)	E+02
			^{238}U	(1.07 ± 0.06)	E+03
			^{238}Pu	(1.6 ± 0.9)	E-01
			$^{239,240}Pu$	(5.3 ± 1.6)	E-01
			Gamma Scan:		
			^{40}K	(7.921 ± 0.506)	E+00
			^{60}Co	(3.592 ± 0.486)	E-01
			^{137}Cs	(5.280 ± 0.688)	E-01
			^{226}Ra	(4.036 ± 0.917)	E-01
			^{235}U	(8.464 ± 0.055)	E+01
			^{238}U	(1.246 ± 0.015)	E+03
			^{228}Th	<1.286	E-01
			^{232}Th	(8.278 ± 1.782)	E-01
B01038	6	7/30-31/91	Gross Alpha	3.09 ± 0.07	E+03
			Gross Beta	1.12 ± 0.01	E+04
			^{90}Sr	(1.2 ± 0.2)	E+01
			^{99}Tc	(3.60 ± 0.08)	E+03
			Total Uranium	(1.6 ± 0.3)	E+04
			^{234}U	(8.79 ± 0.74)	E+03
			^{235}U	(1.6 ± 0.2)	E+03
			^{238}U	(6.03 ± 0.052)	E+03
			^{238}Pu	(1.2 ± 0.4)	E+00
			$^{239,240}Pu$	(4.1 ± 0.9)	E+00
			Gamma Scan:		
			^{40}K	(2.400 ± 0.659)	E+00
			^{60}Co	(7.881 ± 0.976)	E-01
			^{137}Cs	(8.917 ± 1.383)	E-01
			^{226}Ra	(9.942 ± 2.591)	E-01
			^{235}U	(6.384 ± 0.017)	E+02
			^{238}U	(9.143 ± 0.043)	E+03
			^{228}Th	(1.573 ± 0.020)	E+01
			^{232}Th	(1.751 ± 0.380)	E+00

ATTACHMENT 1 RESULTS (page 4)

Customer I.D.	TMA/Norcal Group.No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01040	8	7/30-31/91	Gross Alpha	4.45 ± 0.09	E+03
			Gross Beta	1.22 ± 0.01	E+04
			^{90}Sr	(1.8 ± 0.7)	E+01
			^{99}Tc	(3.45 ± 0.06)	E+03
			Total Uranium	(2.0 ± 0.4)	E+04
			^{234}U	(1.19 ± 0.11)	E+04
			^{235}U	(3.8 ± 3.0)	E+02
			^{238}U	(9.13 ± 0.84)	E+03
			^{238}Pu	(6 ± 4)	E-01
			$^{239,240}Pu$	(4.7 ± 1.5)	E+00
			Gamma Scan:		
			^{40}K	(3.132 ± 0.917)	E+00
			^{60}Co	(9.625 ± 1.340)	E-01
			^{137}Cs	(1.140 ± 0.150)	E+00
			^{226}Ra	(9.713 ± 3.195)	E-01
			^{235}U	(6.910 ± 0.022)	E+02
			^{238}U	(9.659 ± 0.051)	E+03
			^{228}Th	(1.679 ± 0.038)	E+01
			^{232}Th	(1.656 ± 0.478)	E+00
B01041	9	7/31/91	Gross Alpha	11 ± 8	
			Gross Beta	17 ± 3	
			^{90}Sr	(4 ± 48)	E-02
			^{99}Tc	(1.3 ± 0.4)	E+00
			Total Uranium	(1.6 ± 0.3)	E+01
			^{234}U	(1.3 ± 0.2)	E+01
			^{235}U	(2.1 ± 0.5)	E+00
			^{238}U	(8.6 ± 1.2)	E+00
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(0 ± 7)	E-02
			Gamma Scan:		
			^{40}K	(9.360 ± 0.388)	E+00
			^{60}Co	(8.434 ± 2.272)	E-02
			^{137}Cs	(3.751 ± 1.315)	E-02
			^{226}Ra	(3.898 ± 0.365)	E-01
			^{235}U	(3.918 ± 0.764)	E-01
			^{238}U	(4.330 ± 2.477)	E+00
			^{228}Th	(5.627 ± 0.227)	E-01
			^{232}Th	(5.624 ± 0.866)	E-01

ATTACHMENT 1 RESULTS (page 5)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01042	10	7/30-31/91	Gross Alpha	63 ± 13	
			Gross Beta	120 ± 7	
			^{90}Sr	(6 ± 9)	E-01
			^{99}Tc	(2.2 ± 0.1)	E+01
			Total Uranium	(6.2 ± 1.2)	E+01
			^{234}U	(4.6 ± 0.7)	E+01
			^{235}U	(7.4 ± 1.4)	E+00
			^{238}U	(3.3 ± 0.5)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(0 ± 1)	E-01
			Gamma Scan:		
			^{40}K	(9.652 ± 0.497)	E+00
			^{60}Co	(6.691 ± 2.448)	E-02
			^{137}Cs	(3.407 ± 0.325)	E-01
			^{226}Ra	(3.818 ± 0.467)	E-01
			^{235}U	(3.013 ± 0.177)	E+00
			^{238}U	(4.601 ± 0.406)	E+01
			^{228}Th	(6.550 ± 0.445)	E-01
			^{232}Th	(6.510 ± 1.184)	E-01
B01043	11	7/30-31/91	Gross Alpha	24 ± 8	
			Gross Beta	37 ± 4	
			^{90}Sr	(4 ± 10)	E-01
			^{99}Tc	(2.70 ± 0.08)	E+01
			Total Uranium	(1.4 ± 0.3)	E+02
			^{234}U	(1.1 ± 0.1)	E+02
			^{235}U	(1.0 ± 0.3)	E+01
			^{238}U	(7.7 ± 1.0)	E+01
			^{238}Pu	(2.2 ± 0.8)	E-01
			$^{239,240}Pu$	(2.0 ± 0.8)	E-01
			Gamma Scan:		
			^{40}K	(8.846 ± 0.473)	E+00
			^{60}Co	(1.369 ± 0.317)	E-01
			^{137}Cs	(6.079 ± 0.441)	E-01
			^{226}Ra	(4.020 ± 0.595)	E-01
			^{235}U	(8.784 ± 0.200)	E+00
			^{238}U	(1.296 ± 0.061)	E+02
			^{228}Th	(8.045 ± 0.604)	E-01
			^{232}Th	(5.658 ± 1.122)	E-01

ATTACHMENT 1 RESULTS (page 6)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01044	12	7/30-31/91	Gross Alpha	19 ± 8	
			Gross Beta	38 ± 4	
			^{90}Sr	(4 ± 2)	E-01
			^{99}Tc	(1.3 ± 0.1)	E+01
			Total Uranium	(7.5 ± 1.5)	E+01
			^{234}U	(4.2 ± 0.4)	E+01
			^{235}U	(2.9 ± 1.3)	E+00
			^{238}U	(3.0 ± 0.3)	E+01
			^{238}Pu	(6 ± 5)	E-02
			$^{239,240}Pu$	(9 ± 5)	E-02
			Gamma Scan:		
			^{40}K	(9.560 ± 0.434)	E+00
			^{60}Co	(3.088 ± 0.301)	E-01
			^{137}Cs	(6.851 ± 0.360)	E-01
			^{226}Ra	(4.223 ± 0.490)	E-01
			^{235}U	(1.717 ± 0.154)	E+00
			^{238}U	(2.674 ± 0.317)	E+01
			^{228}Th	(6.154 ± 0.290)	E-01
			^{232}Th	(5.833 ± 1.015)	E-01
B01045	13	7/30-31/91	Gross Alpha	8 ± 7	
			Gross Beta	14 ± 4	
			^{90}Sr	(2 ± 6)	E-01
			^{99}Tc	(1.2 ± 0.1)	E+01
			Total Uranium	(1.2 ± 0.2)	E+01
			^{234}U	(5.7 ± 0.7)	E+00
			^{235}U	(6.8 ± 1.8)	E-01
			^{238}U	(4.3 ± 0.6)	E+00
			^{238}Pu	(0 ± 8)	E-02
			$^{239,240}Pu$	(0 ± 6)	E-02
			Gamma Scan:		
			^{40}K	(9.162 ± 0.442)	E+00
			^{60}Co	(4.497 ± 2.085)	E-02
			^{137}Cs	(3.440 ± 0.214)	E-01
			^{226}Ra	(4.342 ± 0.419)	E-01
			^{228}Th	(5.178 ± 0.250)	E-01
			^{232}Th	(5.178 ± 0.930)	E-01

ATTACHMENT 1 RESULTS (page 7)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01046	14	7/30-31/91	Gross Alpha	55 ± 11	
			Gross Beta	81 ± 5	
			^{90}Sr	(6 ± 21)	E-01
			^{99}Tc	(2.4 ± 0.4)	E+01
			Total Uranium	(1.5 ± 0.3)	E+02
			^{234}U	(8.7 ± 0.7)	E+01
			^{235}U	(4.2 ± 2.5)	E+00
			^{238}U	(6.9 ± 0.6)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(3.0 ± 2.3)	E-01
			Gamma Scan:		
			^{40}K	(1.207 ± 0.053)	E+01
			^{60}Co	(1.034 ± 0.051)	E+00
			^{137}Cs	(1.067 ± 0.048)	E+00
			^{226}Ra	(5.547 ± 0.628)	E-01
			^{235}U	(3.443 ± 0.217)	E+00
			^{238}U	(5.318 ± 0.594)	E+01
			^{228}Th	(7.128 ± 0.311)	E-01
			^{232}Th	(6.739 ± 1.367)	E-01

ATTACHMENT 2 QA/QC RESULTS (Page 1)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01032	1	7/30-31/91	Gross Alpha	24 ± 10	
			Gross Beta	30 ± 6	
			^{90}Sr	(2 ± 7)	E-01
			^{99}Tc	(3.8 ± 0.2)	E+00
			Total Uranium	(2.8 ± 0.6)	E+01
			^{234}U	(1.3 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.2 ± 1.0)	E+00
			^{238}Pu	(1.9 ± 1.5)	E-01
			$^{239,240}Pu$	(1.4 ± 0.5)	E+00
			Gamma Scan:		
			^{40}K	(1.058 ± 0.047)	E+01
			^{60}Co	(2.202 ± 0.322)	E-01
			^{137}Cs	(5.229 ± 0.334)	E-01
			^{226}Ra	(4.213 ± 0.449)	E-01
			^{235}U	(6.952 ± 1.100)	E-01
			^{238}U	(9.821 ± 2.557)	E-01
			^{228}Th	(6.424 ± 0.287)	E-01
			^{232}Th	(5.937 ± 1.114)	E-01
B01032	15	7/30-31/91	Gross Alpha	13 ± 8	
			Gross Beta	23 ± 5	
			^{90}Sr	(-6 ± 57)	E-02
			^{99}Tc	(2.2 ± 0.2)	E+00
			Total Uranium	(2.5 ± 0.5)	E+01
			^{234}U	(1.2 ± 0.1)	E+01
			^{235}U	(1.7 ± 0.3)	E+00
			^{238}U	(9.0 ± 1.0)	E+00
			^{238}Pu	(0 ± 6)	E-02
			$^{239,240}Pu$	(2.7 ± 1.0)	E-01
			Gamma Scan:		
			^{40}K	(1.001 ± 0.048)	E+01
			^{60}Co	(1.987 ± 0.304)	E-01
			^{137}Cs	(4.751 ± 0.346)	E-01
			^{226}Ra	(4.168 ± 0.447)	E-01
			^{235}U	(7.590 ± 1.130)	E-01
			^{238}U	(1.107 ± 0.293)	E+01
			^{228}Th	(6.172 ± 0.299)	E-01
			^{232}Th	(5.714 ± 1.139)	E-01

ATTACHMENT 2 QA/QC RESULTS (Page 2)

Customer I.D.	TMA/Norcal Group No. 9513	Collection Date	Analysis	Results pCi/g ±2	
B01046	14	7/30-31/91	Gross Alpha	55 ± 11	
			Gross Beta	81 ± 5	
			^{90}Sr	(6 ± 21)	E-01
			^{99}Tc	(2.4 ± 0.4)	E+01
			Total Uranium	(1.5 ± 0.3)	E+02
			^{234}U	(8.7 ± 0.7)	E+01
			^{235}U	(4.2 ± 2.5)	E+00
			^{238}U	(6.9 ± 0.6)	E+01
			^{238}Pu	(0 ± 2)	E-01
			$^{239,240}Pu$	(3.0 ± 2.3)	E-01
			Gamma Scan:		
			^{40}K	(1.207 ± 0.053)	E+01
			^{60}Co	(1.034 ± 0.051)	E+00
			^{137}Cs	(1.067 ± 0.048)	E+00
			^{226}Ra	(5.547 ± 0.628)	E-01
			^{235}U	(3.443 ± 0.217)	E+00
			^{238}U	(5.318 ± 0.594)	E+01
			^{228}Th	(7.128 ± 0.311)	E-01
			^{232}Th	(6.739 ± 1.367)	E-01
B01046	16	7/30-31/91	Gross Alpha	58 ± 13	
			Gross Beta	110 ± 7	
			^{90}Sr	(4.0 ± 2.5)	E-01
			^{99}Tc	(2.3 ± 0.1)	E+01
			Total Uranium	(1.8 ± 0.4)	E+02
			^{234}U	(8.5 ± 0.8)	E+01
			^{235}U	(6.0 ± 2.0)	E+00
			^{238}U	(6.2 ± 0.6)	E+01
			^{238}Pu	(0 ± 8)	E-02
			$^{239,240}Pu$	(0 ± 8)	E-02
			Gamma Scan:		
			^{40}K	(9.528 ± 0.440)	E+00
			^{60}Co	(8.887 ± 0.457)	E-01
			^{137}Cs	(1.045 ± 0.040)	E+00
			^{226}Ra	(5.524 ± 0.577)	E-01
			^{235}U	(2.934 ± 0.156)	E+00
			^{238}U	(4.510 ± 0.404)	E+01
			^{228}Th	(7.128 ± 0.318)	E-01
			^{232}Th	(7. 9 ± 1.398)	E-01

From: Reactor Physics and Special Studies
Phone: 6-2894 HO-38
Date: August 1, 1991
Subject: CRITICALITY EVALUATION OF 300 AREA TRENCHES

To: G. L. Smith L4-75

cc: P. C. Doto R3-01
N. R. Kerr B1-35
A. E. Waltar HO-32
A. D. Wilcox HO-38
HT-File/LB 9142

References:

1. WHC-CM-4-29, Nuclear Criticality Safety Manual, "Criticality Engineering Analysis," September 15, 1988.

2. Nuclear Criticality Safety Theory and Practice, R. A. Knief, American Nuclear Society, p. 69, 1985.

3. WHC-SP-0193, 300 Area Process Trench Report, December 1987.

4. Criticality Safety of Uranium Metal Scrap in Concrete Billets, American Nuclear Society Transactions, H. Toffer and E. A. Weakley, Vol. 15, Number 1, p. 310-311, June 1972.

SUMMARY

The enrichment, the form, and the amount of uranium in a multi-material matrix makes criticality impossible in the 300 Area process trenches and during subsequent handling of the uranium bearing material.

DETAILS OF ANALYSIS

A detailed assessment of subcriticality for the trench material was performed. The evaluation relied extensively on past analyses and measurements. The evaluation approach considered: an assessment of the average enrichment of the material; nuclear criticality of the uranium in various forms at that enrichment; the impact of the matrix material on criticality; and nuclear criticality for hypothetical scenarios.

The 300 Area trenches were put in use in March of 1975. They received mostly uranium bearing process solutions from the N Reactor fuel fabrication facility. Some limited amounts of solutions containing depleted uranium were added by the Pacific Northwest Laboratory. The concentration of uranium in the trenches (approximately 0.03 g/cc) was too low for any mining considerations and well below concentrations at which neutron multiplication constants would be a maximum (Reference 4).

ENRICHMENT OF THE URANIUM

If the assumption is made that the uranium is typical of the N Reactor fuel, then an average enrichment based on N Reactor throughput can be developed. Considering that the N Reactor is loaded with 300 spike fuel 701 base metal, and 2 natural uranium metal fuel charges:

Spike fuel charge	384 lb	0.947 wt% enriched U
	360 lb	1.25 wt% enriched U
Base charge MKIV	816 lb	0.947 wt% enriched U
Natural charge MKIVB	816 lb	0.72 wt% enriched U

Based on the above listed inventories, an effective enrichment of 0.988 wt% is calculated. This agrees with some enrichment measurements of 0.94 wt% U-235 in uranium of the material in the trench according to E. A. Weakley. Any addition of depleted uranium bearing wastes would lower the 0.988 wt% value. The fact that the effective enrichment of the uranium in the trenches is 1.0 or less has important ramifications on nuclear criticality considerations.

NUCLEAR CRITICALITY OF THE URANIUM IN VARIOUS FORMS

Since the average uranium enrichment of the material in the trenches was determined to be less than 1.0 wt% U-235 in uranium, and all sampling indicates a homogeneous distribution of uranium in the matrix, certain nuclear criticality limits can be established.

Uranium homogeneously distributed in water at optimum moderation with a 1.03 wt% enrichment can not be made critical. In other words, the material has an infinite critical mass. If the uranium assumes some heterogeneous forms, the critical mass for 1.0 wt% uranium will become finite, and according to Reference 2, is 2300 lb (optimum size rods water reflected and optimally moderated). It is highly improbable that the uranium would assume an optimum heterogeneous configuration.

IMPACT OF THE MATRIX MATERIAL ON NUCLEAR CRITICALITY

Reference 3 indicates that the uranium in the trenches is mixed homogeneously with a variety of other elements, mostly metals such as copper, nickel, chromium, etc. Each one of these constituents in a mixture will tend to make the uranium more subcritical or increase critical masses. No explicit calculations were performed, but results in Reference 4 show that small amounts of contaminants have significant impact on critical masses and k-inf values. The reference compares uranium distributed uniformly in water and in concrete, both as a homogeneous mixture and a heterogenous distribution. In either case, the matrix material decreases k-inf values substantially. The effective enrichment of homogeneously distributed uranium in concrete that can be made critical is approximately 1.6 wt%, whereas the value for water is 1.03 wt%. The value for uranium nitrate is 2.1 wt% Any presence of matrix material will make uranium systems be more subcritical.

NUCLEAR CRITICALITY FOR HYPOTHETICAL SCENARIOS

An unrealistic hypothetical scenario can be postulated that assumes all the uranium is of the highest enrichment and that it is in a homogeneous distribution at optimum conditions of moderation and reflection. In Reference 3, a value of total amount of uranium in the trenches was quoted as 720 kg. The safe mass for 1.25 wt% enriched uranium in solution is 3300 lb or 1500 kg uranium (see Reference 2).

It is assumed that all the uranium would become heterogeneously distributed throughout the trench material with optimum moderation and reflection and no matrix materials present. The minimum critical mass would be 2300 kg for 1 wt% and 750 kg for 1.25 wt% uranium enrichment.

CONCLUSION

The uranium present in the trench material has an enrichment that is too low for potential criticality. It is in a homogeneous form and the total mass of uranium is insufficient to support a self-sustaining chain reaction, even under the worst case assumptions. Therefore, it is safe to handle the material from a nuclear criticality perspective.

According to Reference 1, uranium homogeneously distributed in a matrix and having a uranium enrichment of less than or equal to 1 wt% U-235, as well as facilities containing such matrices, are exempt from criticality controls.

Hans Toffer

Hans Toffer, Manager
Reactor Physics and Special Studies

CONCURRENCE: CaR

P. C. Doto, Manager
Criticality Engineering Analysis

kls

Attachment 2

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/μCi-h)
ce-L- 5	30.83 10	4 3	0.0027
ce-L- 6	33.6279 5	1.74 22	0.0012
ce-K- 16	34.109 20	1.72 15	0.0013
ce-MNO- 3	36.2 3	0.4 3	0.0003
ce-MNO- 4	36.78 15	6.7 5	0.0052
ce-K- 18	41.289 20	0.20 19	0.0002
ce-M- 5	46.12 10	1.1 9	0.0011
ce-M- 6	48.9177 3	0.45 7	0.0005
ce-MOP- 5	49.97 10	0.4 3	0.0004
ce-L- 7	52.23 20	4.15 13	0.0046
ce-MOP- 6	52.7705 4	0.163 24	0.0002
ce-K- 19	53.699 20	0.57 6	0.0007
ce-M- 7	67.52 20	1.13 4	0.0016
Auger-K	69.2	0.23 16	0.0003
ce-MOP- 7	71.37 20	0.419 13	0.0006
ce-K- 22	73.05 20	0.6 6	0.0009
ce-K- 23	74.064 5	4.96 15	0.0078
ce-L- 10	75.618 20	0.87 12	0.0014
ce-L- 11	88.668 20	0.107 15	0.0002
ce-MNO-10	90.908 20	0.33 5	0.0006
ce-K- 26	92.469 20	1.1 10	0.0022
ce-K- 27	95.660 10	0.33 3	0.0007
ce-L- 13	99.5279 5	0.521 7	0.0011
ce-MNO-13	114.8177 3	0.196 5	0.0005
ce-L- 16	123.288 20	0.37 3	0.0010
ce-MNO-16	138.578 20	0.120 10	0.0004
ce-L- 19	142.878 20	0.118 11	0.0004
ce-L- 22	162.23 20	0.22 3	0.0008
ce-L- 23	163.243 5	1.00 3	0.0035
ce-MNO-23	178.533 5	0.32778	0.0012
ce-L- 26	181.648 20	0.38 5	0.0015
ce-MNO-26	196.938 20	0.133 14	0.0006
α 1	4150 5	0.90 20	0.0796
α 2	4217 3	5.7 6	0.512
α 3	4219 6	0.9	0.0809
α 4	4271 5	0.4	0.0364
α 5	4325	4.6 5	0.424
α 6	4344	1.5	0.139
α 7	4364 5	11	1.02
α 8	4370 4	6	0.558
α 9	4396 3	55 3	5.15
α 10	4414 4	2.10 20	0.197
α 11	4435 5	0.7	0.0661
α 12	4502.0 20	1.70 20	0.163
α 13	4556.0 20	4.2 3	0.408
α 14	4598.0 20	5.0 5	0.490
X-ray L	13	31 11	0.0086
γ 7	72.70 20	0.1	0.0002
X-ray Ka_2	89.9530 20	2.7 4	0.0052
X-ray Ka_1	93.3500 20	4.5 6	0.0089
X-ray Kβ	105	2.1 3	0.0046
γ 11	109.140 20	1.50 20	0.0035
γ 13	120	0.15	0.0004
γ 15	140.77 8	0.22 3	0.0007
γ 16	143.760 20	10.5 8	0.0322
γ 19	163.350 20	4.7 4	0.0164
γ 22	182.70 20	0.40 5	0.0016
γ 23	183.715 5	54	0.211
γ 24	194.940 10	0.59 6	0.0024
γ 26	202.120 20	1.00 10	0.0043
γ 27	205.311 10	4.7 4	0.0206
γ 29	221.380 20	0.100 10	0.0005

42 weak γ's omitted:
E_γ(avg)= 190.3; ΣI_γ= 0.92%

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/ μCi-h)
• ^{234}Pa β^- Decay (1.17 m 3)		I (min) = 0.10%	
%β Decay = 99.840 18			
Feeds ^{234}U			
See also ^{234}Pa IT Decay (1.17 m)			
Auger-L	9.89	0.35 5	≈0
ce-L- 1	21.723 10	0.476 15	0.0002
ce-MNO- 1	37.932 10	0.1743	0.0001
ce-K- 64	694.4 7	0.3992	0.0059
β^- 1 max	1236 5		
avg	410.2 19	0.74	0.0065
β^- 2 max	1471 5		
avg	500.8 20	0.62	0.0066
β^- 3 max	2281 5		
avg	825.4 21	98.6	1.73
total β^-			
avg	819.2 21	100.14782	1.75
19 weak β's omitted: Eβ(avg)= 208.8; ΣIβ= 0.19%			
X-ray L	13.6	0.44 5	0.0001
X-ray $K\alpha_2$	94.6650 20	0.115 2	0.0002
X-ray $K\alpha_1$	98.4390 20	0.187 4	0.0004
γ 57	766.410 20	0.207 8	0.0034
γ 82	1001.03 3	0.5890 1	0.0126
125 weak γ's omitted: Eγ(avg)= 926.2; ΣIγ= 0.37%			
• ^{234}U α Decay (2.445E5 y 10)		I (min) = 0.10%	
Feeds ^{230}Th			
% Spontaneous Fission = 1.2E-9 6			
Auger-L	9.48	9.7 14	0.0020
ce-L- 1	32.73 5	20.1 18	0.0140
ce-M- 1	48.02 5	5.5 5	0.0056
ce-MOP- 1	51.87 5	2.02 19	0.0022
ce-L- 2	100.428 20	0.139 15	0.0003
α 1	4604.7 20	0.24 3	0.0235
α 2	4723.7 20	27.4 15	2.76
α 3	4775.8 20	72.4 20	7.36
X-ray L	13	10.5 14	0.0029
γ 1	53.20 5	0.118 10	0.0001
9 weak γ's omitted: Eγ(avg)= 121.4; ΣIγ= 0.04%			
• ^{238}U α Decay (7.038E8 y 5)		I (min) = 0.10%	
Feeds ^{234}Th			
% Spontaneous Fission < 4.2E-8			
Auger-L	9.48	29 10	0.0058
ce-L- 2	11.0779 5	18 19	0.0042
ce-MNO- 1	14.4077 3	68 4	0.0209
ce-L- 3	20.9 3	1.2 8	0.0005
ce-L- 4	21.49 15	19.6 10	0.0090
ce-MNO- 2	26.3677 3	7 7	0.0037

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/μCi-h)
• ^{236}Np β^- Decay (1.15E5 y 12)		I (min) = 0.10%	
%β^- Decay = 8.9 20			
Feeds ^{236}Pu			
See also ^{236}Np EC Decay (1.15E5 y)			
Auger-L	10.3	5.9 15	0.0013
ce-L- 1	21.50 10	6.5 15	0.0030
ce-K- 3	38 6	0.3 3	0.0002
ce-MNO- 1	38.67 10	2.4 6	0.0020
ce-L- 2	77 3	6.0 14	0.0099
ce-M- 2	94 3	1.7 4	0.0034
ce-MOP- 2	98 3	0.65 15	0.0018
ce-L- 3	137 6	2.0 21	0.0058
ce-M- 3	154 6	0.6 6	0.0018
ce-MOP- 3	158 6	0.21 22	0.0007
β^- 1 max	195 5		
avg	52.3 15	5 5	0.0056
β^- 2 max	355 3		
avg	105.6 9	5 5	0.0112
total β^-			
avg	78.9 15	10 7	0.0168
X-ray L	14.3	8.8 20	0.0027
γ 2	100 3	0.52 12	0.0011
X-ray $K\alpha_1$	103.76 5	0.13 14	0.0003
γ 3	160 6	1.4 15	0.0049
1 weak γ's omitted:			
$\Sigma\gamma$(avg) = 44.6; $\Sigma I\gamma$ = 0.01%			
• ^{236}Np EC Decay (22.5 h 4)		I (min) = 0.10%	
%EC Decay = 52 1			
Feeds ^{236}U			
See also ^{236}Np β^- Decay (22.5 h)			
Auger-L	9.89	20 3	0.0042
ce-L- 1	23.885 6	5.4 3	0.0027
ce-MNO- 1	39.694 6	1.96 12	0.0017
Auger-K	72.6	0.9 7	0.0013
ce-K- 4	526.72 10	0.155 16	0.0017
X-ray L	13.6	26 3	0.0074
X-ray $K\alpha_2$	94.6650 20	11.26 24	0.0227
X-ray $K\alpha_1$	98.4390 20	18.2 4	0.0382
X-ray Kβ	111	8.50 20	0.0201
γ 4	642.33 10	1.38 8	0.0189
γ 5	687.52 10	0.367 21	0.0054
3 weak γ's omitted:			
$\Sigma\gamma$(avg) = 304.6; $\Sigma I\gamma$ = 0.03%			
• ^{236}Np β^- Decay (22.5 h 4)		I (min) = 0.10%	
%β^- Decay = 48 1			
Feeds ^{236}Pu			
See also ^{236}Np EC Decay (22.5 h)			
Auger-L	10.3	2.4 8	0.0005
ce-L- 1	21.50 10	6.06 23	0.0028
ce-MNO- 1	38.67 10	2.24 8	0.0018

(Continued)

Radiation Type	Energy (keV)	Intensity (%)	Δ(g·rad/ μCi·h)
• ^{235}Np EC Decay (396.1 d 12)		I (min) = 0.10%	
%EC Decay = 99.9986 2			
Feeds ^{235}U			
%α Decay = 0.0014 2			
Auger-L	9.89	30 4	0.0062
X-ray L	13.6	38 5	0.0109
X-ray $K\alpha_2$	94.6650 20	0.51 15	0.0010
X-ray $K\alpha_1$	98.4390 20	0.83 24	0.0017
X-ray Kβ	111	0.39 11	0.0009
• ^{236}U α Decay (2.3415E7 y 14)		I (min) = 0.10%	
Feeds ^{232}Th			
Auger-L	9.48	9.2 17	0.0019
ce-L- 1	28.897 9	19 3	0.0117
ce-MNO- 1	44.187 9	6.9 11	0.0065
ce-L- 2	92.278 15	0.159 7	0.0003
α 1	4332 8	0.260 10	0.0240
α 2	4445 5	26 4	2.46
α 3	4494 3	74 4	7.08
X-ray L	13	10.0 18	0.0028
2 weak γ's omitted:			
Σγ(avg) = 68.2; ΣIγ = 0.11%			
• ^{236}Np EC Decay (1.15E5 y 12)		I (min) = 0.10%	
%EC Decay = 91.1 20			
Feeds ^{236}U			
See also ^{236}Np β^- Decay (1.15E5 y)			
Auger-L	9.89	103 15	0.0217
ce-L- 1	23.485 6	66.6 16	0.0333
ce-MNO- 1	39.694 6	24.4 8	0.0206
ce-K- 3	44.704 9	5.85 22	0.0056
Auger-K	72.6	1.6 12	0.0024
ce-L- 2	82.476 5	60.6 15	0.106
ce-M- 2	98.685 5	16.8 6	0.0352
ce-MOP- 2	102.792 5	6.32 23	0.0138
ce-L- 3	138.553 8	31.7 12	0.0937
ce-M- 3	154.762 8	8.8 4	0.0290
ce-MOP- 3	158.869 8	3.28 13	0.0111
X-ray L	13.6	131 15	0.0380
γ 1	45.242 6	0.152 6	0.0001
X-ray $K\alpha_2$	94.6650 20	20.7 5	0.0417
X-ray $K\alpha_1$	98.4390 20	33.6 7	0.0703
γ 2	104.233 5	7.47 25	0.0166
X-ray Kβ	111	15.6 4	0.0369
γ 3	160.310 8	27.6 6	0.0943

Attachment 3

APPENDIX B

TABLE IV

UNIRRADIATED N REACTOR FUEL ELEMENT
DIMENSIONS AND ISOTOPIC COMPOSITION

	MK IA	MK IV
Outer Tube		
Zirconium Clad OD in. (cm)	2.404 (6.106)	2.425 (6.160)
Uranium OD in. (cm)	2.354 (5.979)	2.375 (6.032)
Uranium ID in. (cm)	1.817 (4.615)	1.741 (4.422)
Zirconium Clad ID in. (cm)	1.767 (4.488)	1.701 (4.320)
Clad Fuel Length in. (cm)	20.88 (53.04)	26.10 (66.29)
Uranium Core Length in. (cm)	20.51 (52.10)	25.73 (65.35)
Weight of Element U lb (kg)	24.45 (11.09)	34.88 (15.82)
Uranium Composition w/o U-235	1.25	0.947
w/o U-238	98.70	99.00
w/o U-234	0.01	0.01
W/o U-236	0.04	0.04
Inner Tube		
Zirconium Clad OD in. (cm)	1.246 (3.165)	1.279 (3.249)
Uranium OD in. (cm)	1 166 (2.962)	1.219 (3.096)
Uranium ID in. (cm)	0.490 (1.245)	0.520 (1.321)
Zirconium Clad ID in. (cm)	0.440 (1.118)	0.480 (1.219)
Clad Fuel Length in. (cm)	20.82 (52.88)	26.04 (66.14)
Uranium Core Length in. (cm)	20.45 (51.94)	25.67 (65.20)
Weight of Element U lb (kg)	12.21 (5.538)	16.30 (7.394)
Uranium Composition w/o U-235	0.947	0.947
w/o U-238	99.00	99.00
w/o U-234	0.01	0.01
w/o U-236	0.04	0.04
Assembly Weight U lb (kg)	36.7 (16.6)	51.2 (23.2)

Density Uranium 18.9 g/cc

Density Zirconium 6.4 g/cc

APPENDIX B

SUPPORTING CALCULATIONS

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RADIOLOGICAL CALCULATIONS

Volume of crib

$50 \text{ ft} \times 60 \text{ ft} \times 30 \text{ ft} = 9 \times 10^4 \text{ ft}^3$

$15.24 \text{ m} \times 18.29 \text{ m} \times 9.14 \text{ m} = 2.55 \times 10^3 \text{ m}^3$

Volume of dump truck

$8 \text{ ft} \times 12 \text{ ft} \times 3 \text{ ft} = 288 \text{ ft}^3$

$2.44 \text{ m} \times 3.66 \text{ m} \times 0.91 \text{ m} = 8.13 \text{ m3}$

Ratio of dump truck volume to volume of crib

$$\frac{8.13 \text{ m}^3}{2.55 \times 10^3 \text{m}^3} = 3.19 \times 10^{-3}$$

Sample dose adjustment

$(3.19 \times 10^{-3}) \times (2811 \text{ mR/hr}) = 8.97 \text{ mR/hr}$ contact on side of dump truck.

WIND DISPERSION MODEL

This model assumes that the dispersable inventory of the crib would be spread over an area of 9 m^2 with a depth of 1 cm. This assumption would subject a portion of the inventory to resuspension by wind erosion. These assumption are conservative in nature.

Where

Concentration of ^{60}Co dust at 100 m = 2.2×10^{-12} mg/m^3

$(2.2 \times 10^{-12} \text{ mg/m}^3) \times (1.13 \times 10^6 \text{ uCi/mg}) = 2.49 \times 10^{-6} \text{ uCi/m}^3$

Derived air concentration (DAC) $^{60}Co = 1.0 \times 10^{-8}$ uCi/ml or 1.0×10^{-2} uCi/m^3

Derived concentration guide (DCG) $^{60}Co = 8.0 \times 10^{-11}$ uCi/ml or 8.0×10^{-5} uCi/m^3

^{60} Co concentration at 100 m = $\frac{2.49 \times 10^{-6} \text{ uCi/m}^3}{1.0 \times 10^{-2} \text{uCi/m}^3} = 2.49 \times 10^{-4}$ DACs/m^3

Where the respiration rate is

$1.2 \text{ m}^3/\text{hr}$

The intake rate is

$(1.2 \text{ m}^3/\text{hr}) \times (2.49 \times 10^{-4} \text{ DACs/hr}) = 2.99 \times 10^{-4}$ DACs/hr

8,760 hrs x 1 DCG = 0.1 rem effective dose equivalent (EDE)

2,000 hrs x 1 DAC/hr = 5 rem EDE

At 0.1 DAC, respiratory protection is required.

Therefore, at 100 m and using the most conservative model available, the air concentration for the most limiting isotope within the crib would not reach a level requiring public concern (DCG). Consequently, the exposure to the site worker, uninvolved site worker, and the public receptor would be well below the risk acceptance limits as defined in WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*.

Because the model is not reliable for concentrations at less than 100 m, we may use a conservative estimate for dust loading and multiply contaminant concentration per gram of soil by dustloading per unit volume of air. This enables us to make a conservative estimate of the airborne potential to the facility worker.

Dust loading = 10 mg/m^3 in air

^{60}Co 3.7 x 10^4 pCi/g in soil

(1.0 x 10^{-2} g/m^3) x (3.7 x 10^{-2} uCi/g) = 3.7 x 10^{-4} uCi/m^3 or 3.7 x 10^{-10} uCi/cm^3

CHEMICAL CALCULATIONS

Calculations for release of chemical contaminants are based upon a source term for 9 m^2, the surface area of soil in the dump truck and a depth of one centimeter. This is the volume of soil subject to resuspension.

Where

97 ft^2 = the area of the dump truck.

In the following calculations we see the dimensions of a circle

1/4 pi D^2 = area

97 = 1/4 pi D^2

11.11 ft = diameter

1/2 D = radius

5.56 ft (1.69 m) (parameter for model input) = radius

14.9 mi/hr (or 6.7 m/s) (parameter for model input) = wind velocity. A minimum of 13 mi/hr is required to resuspend dust; below 13 mi/hr, resuspension is not possible. At 15 mi/hr, regulations require activities at the Hanford Site be suspended because of the possibility of contamination being spread by wind.

Conversion of the top centimeter of soil to grams

$97\ ft^2 \times 0.0328\ ft = 3.2\ ft^3 = 9.1\ E^4\ cm^3$

Conversion of volume to weight

$(9.1\ E^4\ cm^3) \times (2\ g/cm^3) = 1.82\ E^5$ g of soil subject to resuspension.

Release rate example (Ag)

$(1.82\ E^5$ g of soil) x (362 ug Ag/g of soil) x ($3.5\ E^{-6}$/s release rate fraction) = $2.3\ E^{-4}$ g/s Ag (parameter for model input)

Where

6.7 m/s = wind speed (parameter)

1.69 m (parameter) = radius

$3.5\ E^{-6}$ /s = release rate fraction

($2.5\ E^{-4}$ g/s) Ag (parameter).

Table B-1 provides a summation of models by contaminants.

Table B-1. Summation of Model by Contaminant (mg/m^3).

Distance in meters	Silver	Chromium	Copper	Nickel	Uranium	Arrival time in minutes
5,000	$2.7\ 10^{-7}$	$4.6\ 10^{-7}$	$7.0\ 10^{-5}$	$1.3\ 10^{-6}$	$7.1\ 10^{-6}$	12
4,000	$3.8\ 10^{-7}$	$6.3\ 10^{-7}$	$9.8\ 10^{-5}$	$1.8\ 10^{-6}$	$9.8\ 10^{-6}$	10
3,000	$5.8\ 10^{-7}$	$9.7\ 10^{-7}$	$1.5\ 10^{-4}$	$2.8\ 10^{-6}$	$1.5\ 10^{-5}$	7
2,000	$1.1\ 10^{-6}$	$1.8\ 10^{-6}$	$2.8\ 10^{-4}$	$5.3\ 10^{-6}$	$2.8\ 10^{-5}$	5
1,000	$3.3\ 10^{-6}$	$5.6\ 10^{-6}$	$8.6\ 10^{-4}$	$1.6\ 10^{-5}$	$8.7\ 10^{-5}$	2
900	$4.0\ 10^{-6}$	$6.6\ 10^{-6}$	$1.0\ 10^{-3}$	$1.9\ 10^{-5}$	$1.0\ 10^{-4}$	2
800	$4.8\ 10^{-6}$	$8.1\ 10^{-6}$	$1.3\ 10^{-3}$	$2.4\ 10^{-5}$	$1.3\ 10^{-4}$	2
700	$6.1\ 10^{-6}$	$1.0\ 10^{-5}$	$1.6\ 10^{-3}$	$3.0\ 10^{-5}$	$1.6\ 10^{-4}$	2
600	$7.9\ 10^{-6}$	$1.3\ 10^{-5}$	$2.0\ 10^{-3}$	$3.9\ 10^{-5}$	$2.1\ 10^{-4}$	1
500	$1.1\ 10^{-5}$	$1.8\ 10^{-5}$	$2.8\ 10^{-3}$	$5.3\ 10^{-5}$	$2.8\ 10^{-4}$	1
400	$1.6\ 10^{-5}$	$2.7\ 10^{-5}$	$4.2\ 10^{-3}$	$7.8\ 10^{-5}$	$4.2\ 10^{-4}$	1
300	$2.7\ 10^{-5}$	$4.5\ 10^{-5}$	$6.9\ 10^{-3}$	$1.3\ 10^{-4}$	$7.0\ 10^{-4}$	1
200	$5.5\ 10^{-5}$	$9.3\ 10^{-5}$	$1.4\ 10^{-2}$	$2.7\ 10^{-4}$	$1.4\ 10^{-3}$	0
100	$1.9\ 10^{-4}$	$3.2\ 10^{-4}$	$4.9\ 10^{-2}$	$9.3\ 10^{-4}$	$4.9\ 10^{-3}$	0

CALCULATIONS FOR WATER TREATMENT

In the 300 Area, approximately 1.51 x 10^5 L (40,000 gal) of washwater is currently stored in "fract" tanks. Approximately 5% of that quantity will be precipitated out via a water treatment system (7.55 x 10^3 L). The water treatment system is described in Appendix D.

(1.51 x 10^5 L) X 0.05 = 7.55 X 10^3 L of solids

The effluent will be pumped into BF-25 boxes for disposal.

The dimensions of BF-25 boxes are as follows:

(1.22 m) x (1.5 m) x (1.83 m)= 3.39 m^3

3.39 m^3 = 3.39 x 10^3 L/ BF-25 burial box

4 x (3.39 x 10^3 L) = 1.36 x 10^4 L (total volume of four BF-25 boxes)

CONCENTRATION OF CONTAMINANTS IN WATER

Average concentration of uranium concentration in 7 water samples taken was 40 mg/L; the range of samples was 10,200 to 93,700 ug/L.

(4.0 x 10^{-5} kg/L) x (1.51 x 10^5 L of water) = 6.04 Kg (13.32 lb) of U in the stored water. Expected removal of contaminants is at 95% efficiency; therefore

0.95 x 6.04 Kg = 5.74 Kg (12.65 lb) of U in the burial boxes.

5.74 Kg divided by 4 boxes = 1.44 Kg of U per burial box.

Using the above method, and anticipating equivalent extraction, expected weights of other contaminants follow.

Silver	Avg = 0.53 mg/L	= 0.076 Kg total removed	= 0.019 Kg/box
Chromium	Avg = 5.77 mg/L	= 0.83 Kg total removed	= 0.21 Kg/box
Copper	Avg = 44.5 mg/L	= 6.38 Kg total removed	= 1.6 Kg/box
Nickel	Avg = 4.99 mg/L	= 0.75 Kg total removed	= 0.19 Kg/box

The system is set up to reprocess water that does not extract all contaminants; therefore, water will continuously be processed through the system to as low as reasonably achievable.

EXAMPLE CALCULATION FOR RESIDUAL CONTAMINANTS IN PROCESSED WATER

Where

0.53 mg/L = average concentration of silver in water used in soil washing.

(0.53 mg/L of silver) x (1.51×10^5 L of water) = 8.00×10^1 g Ag total.

If 95% of silver is removed, 0.4 g of silver will remain in the treated water. Also, $7.55\ 10^3$ L of solids were removed. Therefore, 1.51×10^5 L minus 7.55×10^3 L = 1.43×10^5 L of water remaining.

$$\frac{0.4 \text{ g silver}}{1.43 \times 10^5 \text{ L}} = 2.8 \times 10^{-6} \text{g/L} \quad \text{or} \quad 2.8 \times 10^{-3} \text{ mg/L of silver in water}$$

Table B-2. Residual Contaminants in Processed Water.

Remaining contaminants in treated water	Concentration in mg/l	Standards for groundwater*
Silver	2.8×10^{-3} mg/L	0.05 mg/L
Chromium	3.05×10^{-1} mg/L	0.05 mg/L
Copper	1.78 mg/L	1.0 mg/L
Nickel	2.63×10^{-1} mg/L	--
Uranium	4.56 X 10 nCi/L	15 pCi/L

*Source: WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.

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EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : SILVER Library-91
Molecular Weight : 107.9 gram/mole
CAS Number: [7440-22-4]
TWA : 0.0100 mg/m^3

AREA, CONTINUOUS : 2.3E-04 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 1.9E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	1.9E-04	0: 0
0.20	5.5E-05	0: 0
0.30	2.7E-05	0: 1
0.40	1.6E-05	0: 1
0.50	1.1E-05	0: 1
0.60	7.9E-06	0: 1
0.70	6.1E-06	0: 2
0.80	4.8E-06	0: 2
0.90	4.0E-06	0: 2
1.00	3.3E-06	0: 2
2.00	1.1E-06	0: 5
3.00	5.8E-07	0: 7
4.00	3.8E-07	0:10
5.00	2.7E-07	0:12
6.00	2.1E-07	0:15
7.00	1.7E-07	0:17
8.00	1.4E-07	0:20
9.00	1.2E-07	0:22
10.0	1.0E-07	0:25
20.0	4.1E-08	0:50
40.0	1.7E-08	1:40
60.0	1.0E-08	2:29
80.0	7.2E-09	3:19
100	5.5E-09	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : CHROMIUM Library-91
Molecular Weight : 52.0 gram/mole
CAS Number: [7440-47-3]
TWA : 0.50 mg/m^3
IDLH : 500 mg/m^3

AREA, CONTINUOUS : 3.8E-04 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 3.2E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	3.2E-04	0: 0
0.20	9.3E-05	0: 0
0.30	4.5E-05	0: 1
0.40	2.7E-05	0: 1
0.50	1.8E-05	0: 1
0.60	1.3E-05	0: 1
0.70	1.0E-05	0: 2
0.80	8.1E-06	0: 2
0.90	6.6E-06	0: 2
1.00	5.6E-06	0: 2
2.00	1.8E-06	0: 5
3.00	9.7E-07	0: 7
4.00	6.3E-07	0:10
5.00	4.6E-07	0:12
6.00	3.5E-07	0:15
7.00	2.8E-07	0:17
8.00	2.4E-07	0:20
9.00	2.0E-07	0:22
10.0	1.7E-07	0:25
20.0	6.9E-08	0:50
40.0	2.9E-08	1:40
60.0	1.7E-08	2:29
80.0	1.2E-08	3:19
100	9.2E-09	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : COPPER Library-91
Molecular Weight : 63.5 gram/mole
CAS Number: [7440-50-8]
TWA : 0.20 mg/m^3

AREA, CONTINUOUS : 6.0E-02 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 4.9E-02 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	0.049	0: 0
0.20	0.014	0: 0
0.30	0.0069	0: 1
0.40	0.0042	0: 1
0.50	0.0028	0: 1
0.60	0.0020	0: 1
0.70	0.0016	0: 2
0.80	0.0013	0: 2
0.90	0.0010	0: 2
1.00	8.6E-04	0: 2
2.00	2.8E-04	0: 5
3.00	1.5E-04	0: 7
4.00	9.8E-05	0:10
5.00	7.0E-05	0:12
6.00	5.4E-05	0:15
7.00	4.4E-05	0:17
8.00	3.6E-05	0:20
9.00	3.1E-05	0:22
10.0	2.7E-05	0:25
20.0	1.1E-05	0:50
40.0	4.4E-06	1:40
60.0	2.7E-06	2:29
80.0	1.9E-06	3:19
100	1.4E-06	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : NICKEL Library-91
Molecular Weight : 58.7 gram/mole
CAS Number: [7440-02-0]
TWA : 0.100 mg/m^3

AREA, CONTINUOUS : 1.1E-03 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED : 6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 9.3E-04 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	9.3E-04	0: 0
0.20	2.7E-04	0: 0
0.30	1.3E-04	0: 1
0.40	7.8E-05	0: 1
0.50	5.3E-05	0: 1
0.60	3.9E-05	0: 1
0.70	3.0E-05	0: 2
0.80	2.4E-05	0: 2
0.90	1.9E-05	0: 2
1.00	1.6E-05	0: 2
2.00	5.3E-06	0: 5
3.00	2.8E-06	0: 7
4.00	1.8E-06	0:10
5.00	1.3E-06	0:12
6.00	1.0E-06	0:15
7.00	8.2E-07	0:17
8.00	6.8E-07	0:20
9.00	5.8E-07	0:22
10.0	5.1E-07	0:25
20.0	2.0E-07	0:50
40.0	8.3E-08	1:40
60.0	5.0E-08	2:29
80.0	3.5E-08	3:19
100	2.7E-08	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : URANIUM Library-XY
Molecular Weight : 238.0 gram/mole
CAS Number: [7440-61-1]
TWA : 0.20 mg/m^3
STEL : 0.60 mg/m^3
IDLH : 20 mg/m^3

AREA, CONTINUOUS : 6.0E-03 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > 4.9E-03 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	0.0049	0: 0
0.20	0.0014	0: 0
0.30	7.0E-04	0: 1
0.40	4.2E-04	0: 1
0.50	2.8E-04	0: 1
0.60	2.1E-04	0: 1
0.70	1.6E-04	0: 2
0.80	1.3E-04	0: 2
0.90	1.0E-04	0: 2
1.00	8.7E-05	0: 2
2.00	2.8E-05	0: 5
3.00	1.5E-05	0: 7
4.00	9.8E-06	0:10
5.00	7.1E-06	0:12
6.00	5.4E-06	0:15
7.00	4.4E-06	0:17
8.00	3.6E-06	0:20
9.00	3.1E-06	0:22
10.0	2.7E-06	0:25
20.0	1.1E-06	0:50
40.0	4.4E-07	1:40
60.0	2.7E-07	2:29
80.0	1.9E-07	3:19
100	1.4E-07	4: 9

EPIcode 4.1 S/N 12149 BATTELLE
SUBSTANCE I.D. : COBALT 60 Library-

ERPG-1 : 335610718480000000000000000000000000000 ppm ERPG-2 : 3074059592900000000

AREA, CONTINUOUS : 2.7E-12 gram/sec

HEIGHT-EFFECTIVE: 0 Meters
RADIUS OF SOURCE : 1.69 Meters
SURFACE WIND SPEED :6.7 Meters/second
DEPOSITION VELOCITY: 1.000 cm/second
STABILITY CLASS : D
TERRAIN : STANDARD
RECEPTOR HEIGHT (z) : 0 Meters
LOCATION OF MAXIMUM CONCENTRATION LEVEL
Distance : < 0.10km
Level : > < 0.0001 mg/m^3

DOWNWIND Distance-km	CONCENTRATION mg/m^3	ARRIVAL TIME hours:minutes
0.10	2.2E-12	0: 0
0.20	6.4E-13	0: 0
0.30	3.1E-13	0: 1
0.40	1.9E-13	0: 1
0.50	1.3E-13	0: 1
0.60	9.1E-14	0: 1
0.70	7.0E-14	0: 2
0.80	5.6E-14	0: 2
0.90	4.6E-14	0: 2
1.00	3.8E-14	0: 2
2.00	1.2E-14	0: 5
3.00	6.7E-15	0: 7
4.00	4.3E-15	0:10
5.00	3.1E-15	0:12
6.00	2.4E-15	0:15
7.00	1.9E-15	0:17
8.00	1.6E-15	0:20
9.00	1.4E-15	0:22
10.0	1.2E-15	0:25
20.0	4.7E-16	0:50
40.0	2.0E-16	1:40
60.0	1.2E-16	2:29
80.0	8.3E-17	3:19
100	6.4E-17	4: 9

APPENDIX C

MODIFIED ENVIRONMENTAL PROTECTION AGENCY SOILS WASHING SYSTEM

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The oversize (2- to 0.425-mm or 0.210-mm) material from the secondary screen will exit the system as clean material. The undersize (-0.425- or -0.210-mm) material will leave the screen as a slurry. This slurry will be stored in fractionation (frac) tanks and treated after the test is completed. The anticipated treatment will consist of filtering the fines out and containing them in low specific activity boxes and then transporting the water to the purge water tanks for evaporation. More detail about the low specific activity containers is given in Attachment A, Chapter 4, Water Treatment And Residual Handling.

An operating and maintenance manual for the trommel trailer will provide the required procedures for setup, startup, operation, shutdown, teardown, and maintenance. This manual came with the equipment when transferred to DOE, Richland Operations (RL) from the EPA Risk Reduction Engineering Laboratory.

The system will be set up initially using some baseline operating parameters. These parameters may be altered during operation and the changes will be detailed in the final report. The baseline operating parameters are as follows:

Primary Screen:	
Area	0.75 by 2.4 m (2.5 by 8 ft)
Size	25.4 mm (1.0 in.)
Slope	0.0 deg
Soil Flowrate	8.2 dmt/hr (9.0 dst/hr)
Nozzle Pressure	2.8 kg/cm^2 (40 lb/in^2)
Nozzle Flowrate (total)	38 L/min (10 gal/min)
Underflow percent solids	1.2% solids by weight
Trommel:	
Size	1.37-m dia. by 6.4 m (4.5 by 21 ft)
Speed	2.9 rpm
Angle	3.0 deg
Screen Size	2.0 mm (0.08 in.)
Soil Flowrate	3.6 mt/hr (4.0 st/hr)
Underflow Percent Solids	10.2% solids by weight
Retention Time	21 min.
Initial Rinse: (15)	
Pressure	4.2 kg/cm^2 (60 lb/in^2)
Flowrate (total)	600 L/min (160 gal/min)
Final Rinse: (9)	
Pressure	2.8 kg/cm^2 (40 lb/in^2)
Flowrate (total)	265 L/min (70 gal/min)
Secondary Screen:	
Area	0.56 by 2.1 m (1.8 by 7 ft)
Size-Test #1	0.425 mm (0.02 in.)
Size-Test #1	0.210 mm (0.01 in.)
Slope	0.0 deg
Soil Flowrate	2.1 mt/hr (2.3 st/hr)
Underflow Percent Solids	
-Test #1	2.8% solids by weight
-Test #2	1.4% solids by weight

Figure C-1. Environmental Protection Agency Modified Soil Washing System.

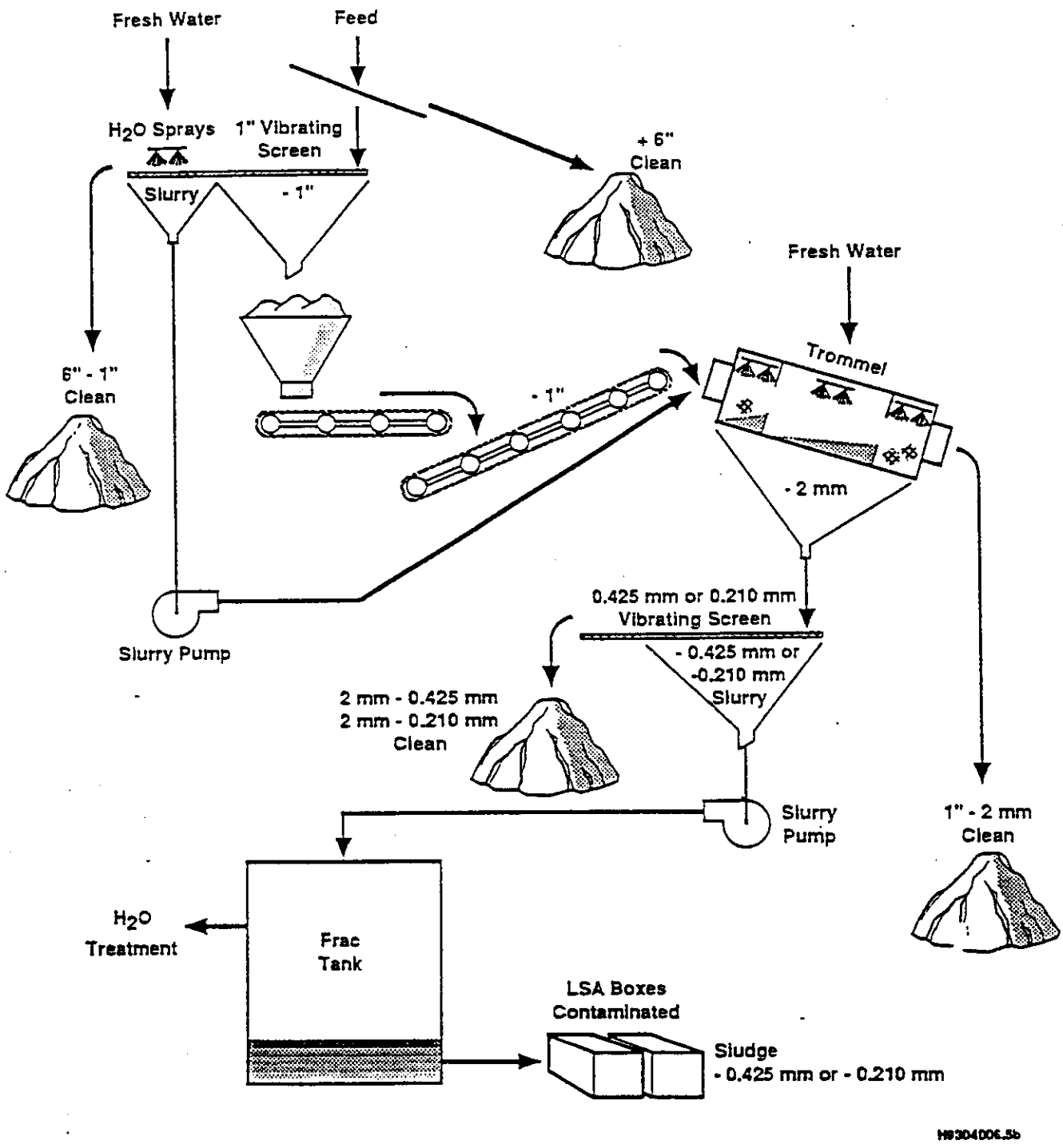
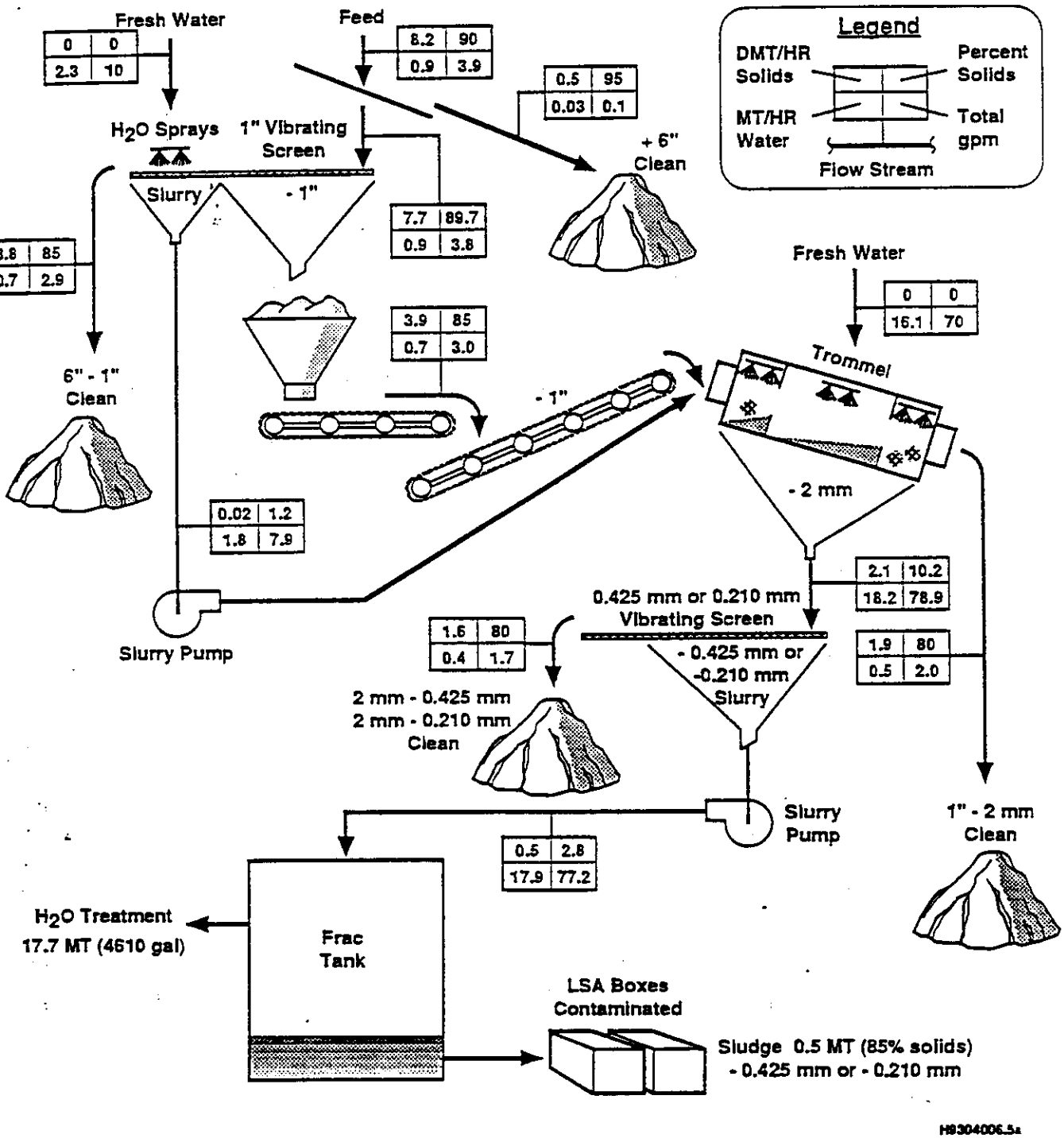


Figure C-2. Modified Environmental Protection Agency Soil Washing System - Baseline Material Balance (per hour of Operation.



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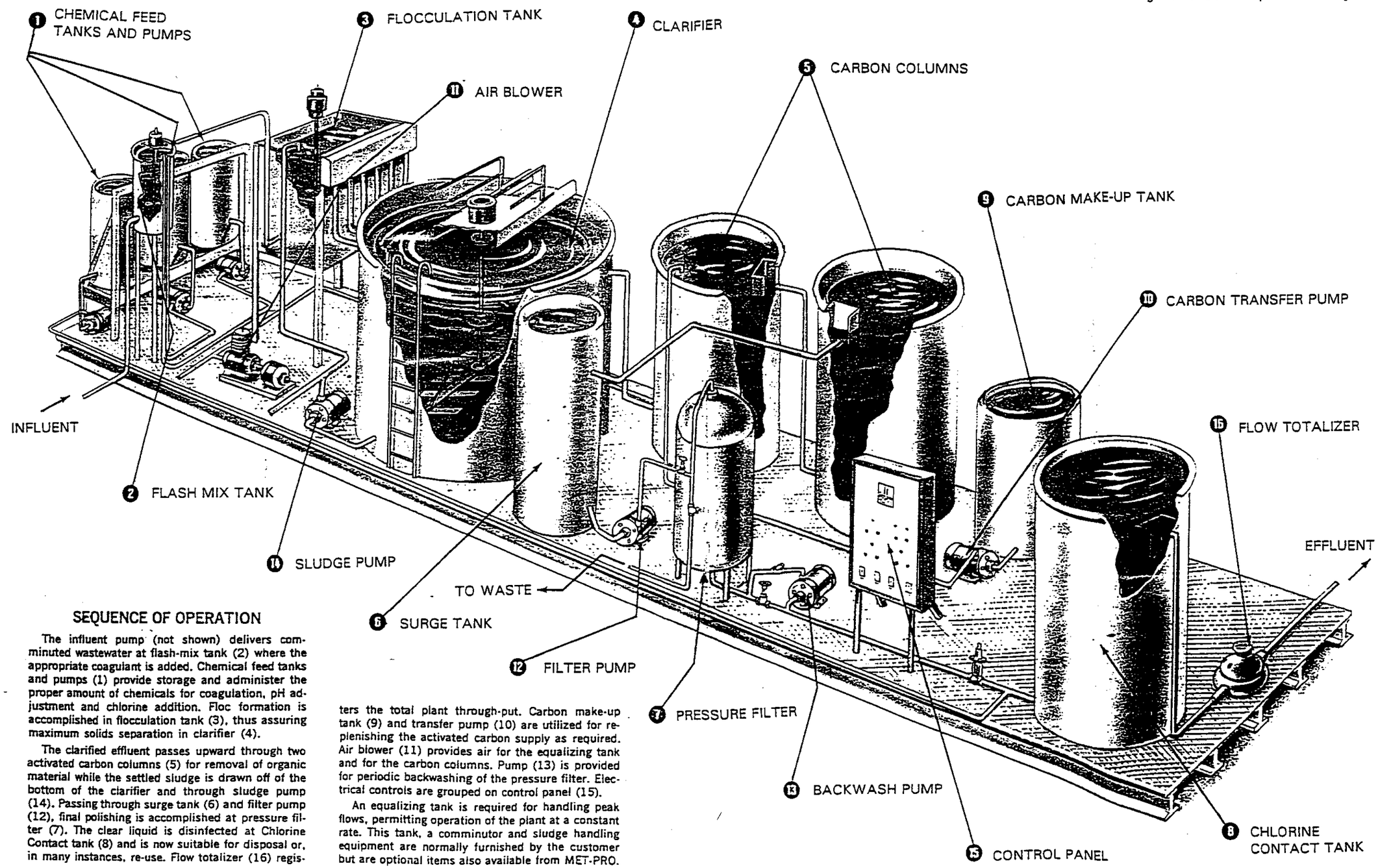
APPENDIX D

WATER TREATMENT SYSTEM

Figure D-1. Sequence of System Operation.



SEQUENCE OF OPERATION

The influent pump (not shown) delivers comminuted wastewater at flash-mix tank (2) where the appropriate coagulant is added. Chemical feed tanks and pumps (1) provide storage and administer the proper amount of chemicals for coagulation, pH adjustment and chlorine addition. Floc formation is accomplished in flocculation tank (3), thus assuring maximum solids separation in clarifier (4).

The clarified effluent passes upward through two activated carbon columns (5) for removal of organic material while the settled sludge is drawn off of the bottom of the clarifier and through sludge pump (14). Passing through surge tank (6) and filter pump (12), final polishing is accomplished at pressure filter (7). The clear liquid is disinfected at Chlorine Contact tank (8) and is now suitable for disposal or, in many instances, re-use. Flow totalizer (16) registers the total plant through-put. Carbon make-up tank (9) and transfer pump (10) are utilized for replenishing the activated carbon supply as required. Air blower (11) provides air for the equalizing tank and for the carbon columns. Pump (13) is provided for periodic backwashing of the pressure filter. Electrical controls are grouped on control panel (15).

An equalizing tank is required for handling peak flows, permitting operation of the plant at a constant rate. This tank, a comminutor and sludge handling equipment are normally furnished by the customer but are optional items also available from MET-PRO.

Note: Illustrations and text refer to the Series 12000 IPC Systems. Other designs also available from MET-PRO.

*MET-PRO is a registered tradename of MET-PRO Corp., Harleysville, Pennsylvania.

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TANKAGE

Title	Dimensions (Diameter) Inches	Dimensions (Height) Inches	Full Volume (Gal.)	Residence Time (Min.)
Flash Mix	20	48	65	1.86
Flocculation	48x48 Sq.	57	570	16.2
Clarifier	120	96	4,710	135
Acid Mix	22	36	75	2.16
Upflow Adsorber	48	96	756 @ 35 gpm =	21.6
Downflow Adsorber	48	96	756	21.6
Pressure Filter	36	60	(1)	(1)
Surge	36	96	424	12
Chlorine Contact	60	96	1,178	33.6
Chemical Feed	24	48	94	(2)
Lime Slurry	48	48	360	(2)

Note: This is not the operating volume, so residence times shown will be lower.

(1) 4.95 GPM/square foot surface.
(2) Usually 1-1/2 days storage.

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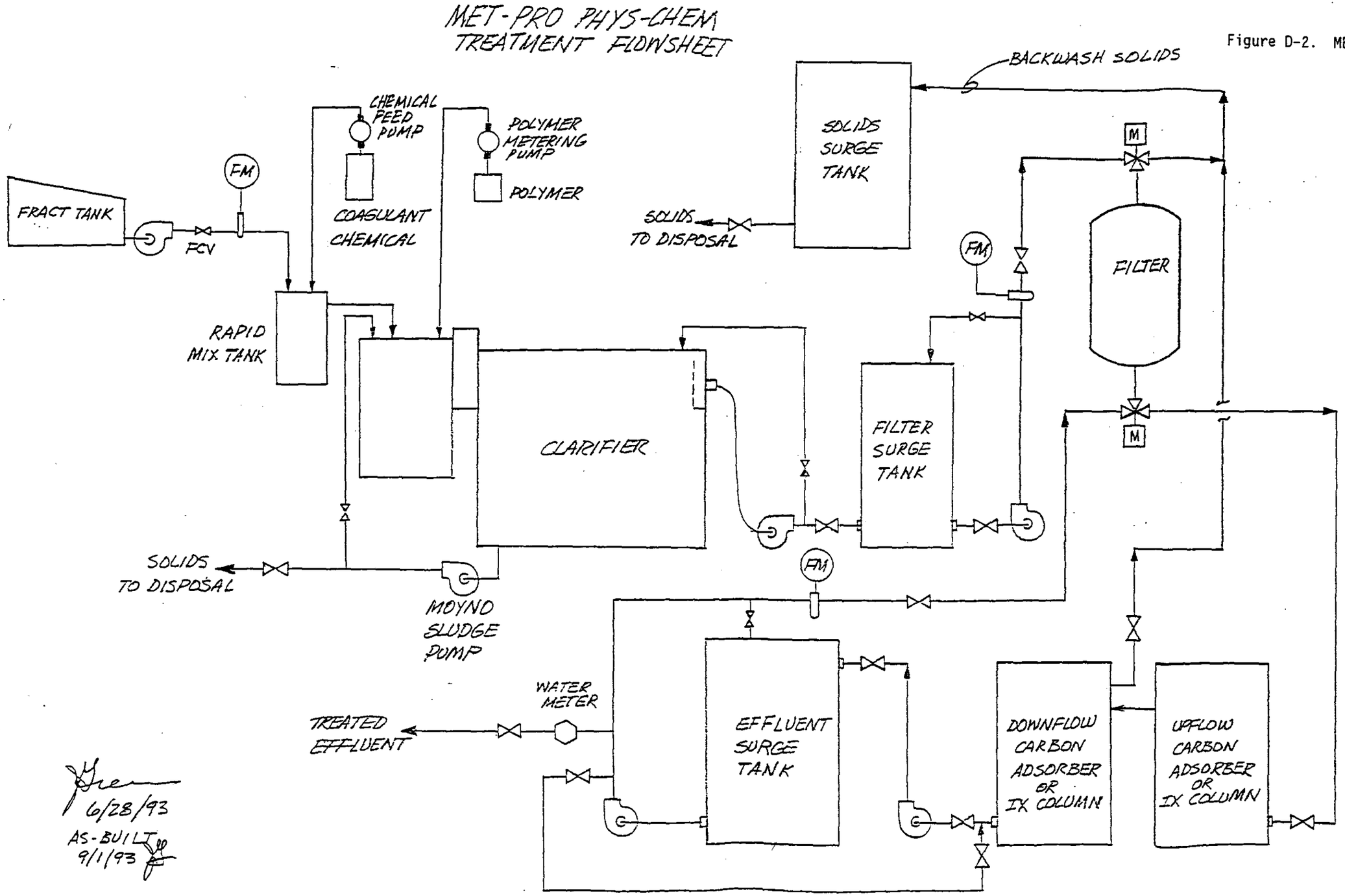
Figure D-2. MET-PRO Treatment Flowsheet.



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300 AREA SOIL WASHING RESULTS

	MINUS 0.425mm SLURRY WATER (UNFILTERED) JUNE 1993 PROCESSING							MINUS 0.425mm SLURRY SOILS JUNE 1993 PROCESSING						
	B07C75 water mg/L	B07C76 water mg/L	B07C77 water mg/L	B07C85 water mg/L	B07C79 water mg/L	B07C80 water mg/L	B07C81 water mg/L	B07C91 soil mg/kg	B07C92 soil mg/kg	B07C93 soil mg/kg	B07C95 soil mg/kg	B07C96 soil mg/kg	B07C97 soil mg/kg	B07CB1 soil mg/kg
Ag	0.05	1	0.53	0.98	0.64	0.3	0.18	2.1	1.5 L	1.1 L	2.2	1.5 L	2.8	1.9 L
Al	37	850	550	770	1000	480	250	7600	7800	7100	8900	10000	9900	6900
As	0.003 L	0.024	0.028	0.026	0.023	0.022	0.011	1.3	1.2	1.2	2.2	1.1	1.7	1
Ba	2.1	67	43	60	120	59	27	220	200	190	310	380	390	300
Be	0.0013 L	0.019	0.011	0.018	0.018	0.0082	0.0042	0.24 L	0.23 L	0.18 L	0.1 L	0.22 L	0.2 L	0.21 L
Ca	19	400	170	400	350	170	100	3900	4000	3800	5100	5000	5400	4100
Cd	0 U	0.011	0 U	0.0091 L	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Co	0.0071 L	0.095	0.14	0.092	0.27	0.13	0.066	3.6	4.6	4.9	6	4.7	5.3	5
Cr	0.38	9.2	5.5	8.6	9.5	4.6	2.6	34	30	28	45	44	53	40
Cu	3.5	100	50	98	60	29	25	320	240	150	420	420	500	260
Fe	13	230	160	220	270	130	63	12000	13000	15000	19000	14000	15000	14000
Hg	0.0045	0.13	0.078	0.14	0.12	0.096	0.049	0.3 L	0.2 L	0.35 L	0.49	0.3 L	0.46	0.54
K	3.5	34	24	33	37	18	9.2	670	750	730	800	810	790	650
Mg	10	190	120	170	210	100	59	3100	3100	3300	3800	3700	3700	3200
Mn	0.27	5.3	3.7	4.9	6	2.9	1.6	160	160	200	220	180	180	170
Na	31	120	110	120	170	96	66	640	650	650	710	890	900	620
Ni	0.32	10	5	9.6	5.3	2.7	2	34	27	22	40	30	47	29
Pb	0.093	2.6	1.1	2.1	2.1	0.98	0.55	13	13	11	18	15	24	17
Sb	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U	4.4 L	0 U	0 U	4.5 L	0 U
Sn	0.061 L	1	0.68	0.89	1.3	0.67	0.38	0 U	6 L	0 U	0 U	6.1 L	0 U	0 U
V	0.0089 L	0.36	0.22	0.36	0.4	0.19	0.097	37	38	48	61	42	45	39
Zn	0.11	2.6	1.7	2.4	3	1.5	0.89	35	36	37	44	42	44	39

	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Co-60	-2.58	2.19	11.9	0.877	-3.78	18.6	-3.72	-0.000	-0.013	-0.008	-0.006	0.0090	0.0073	0.0077
Cs-137	1.32	0.0867	9.56	5.47	4.86	7.43	25.1	0.152	0.118	0.138	0.174	0.279	0.303	0.224
Pb-212								0.596	0.604	0.834	0.828	0.724	0.821	0.917
Pb-214								0.511	0.403	0.556	0.424	0.518	0.478	0.619
Ra-224								0.608	0.616	0.85	0.84	0.734	0.832	0.55
Ra-226								0.461	0.459	0.534	0.448	0.456	0.509	0.929
Ru-106	23.3	47.9	-67	-20.6	-75.7	80.8	-28.4	0.0369	0.209	0.0928	0.0307	-0.142	0.446	0.0867
Sb-125	-12.2	-3.67	42.3	-2.11	27.7	-38.7	30.2	0.0251	0.0062	0.0726	0.0429	0.0428	-0.070	-0.073

	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
U-Nat	10200	24800	50000	30600	93700	38500	23400	217	214	158	173	358	355	827

MATERIAL SAFETY DATA SHEET

Calgon Corporation
P.O. Box 1346
Pittsburgh, PA 15230-1346

24 Hour Emergency Telephone--(412)777-8000

SUBSIDIARY OF MERCK & CO., INC.

Section 1. PRODUCT IDENTIFICATION

PRODUCT NAME: Cat-Floc L

CHEMICAL DESCRIPTION: Aqueous solution of cationic polymer
PRODUCT CLASS: Water treatment
MSDS CODE: 0170-10-22-91

Section 2. HAZARDOUS INGREDIENTS AND EXPOSURE LIMITS

Chemical Name	CAS Number	% by Weight	OSHA PEL	ACGIH TLV

"No ingredients listed in this section"

HAZARD COMMUNICATION STATUS: This product is not considered to be hazardous according to the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200.

Section 3. HAZARDS IDENTIFICATION

********** EMERGENCY OVERVIEW **********

This product poses little or no immediate hazard.

****

PRIMARY ROUTES OF ENTRY: None

TARGET ORGANS: None

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Unknown

MATERIAL SAFETY DATA SHEET

POTENTIAL HEALTH EFFECTS:

EYE CONTACT: This product would not be expected to produce irritation upon contact with the eye.

SKIN CONTACT: The product is not expected to cause skin irritation upon contact. Data indicate that this product will not produce an allergic skin reaction or be absorbed through the skin in harmful amounts.

INGESTION: This product would be expected to be practically non-toxic by ingestion.

INHALATION: This product is not expected to present an inhalation hazard.

SUBCHRONIC, CHRONIC:
In a subchronic toxicity study using rats, the active ingredient of this product was administered orally at doses of 5, 50, and 500 mg/kg. Animals in the 50 mg/kg group showed decreased weight gain, decreased food consumption and increased sleeping time. Animals in the 500 mg/kg group showed decreased weight gain, decreased food consumption, and alterations in red blood cells and blood proteins. Animals in the 5 mg/kg group showed no effects. Twelve-month feeding studies using rats and dogs given 2 and 200 ppm active ingredient in drinking water showed no significant adverse effects.

A similar product has been shown not to be mutagenic by the Ames assay. A teratology study in rabbits and a two-generation reproduction study in rats showed this product did not produce birth defects or affect reproduction.

CARCINOGENICITY:
NTP:
No ingredients listed in this section
IARC:
No ingredients listed in this section
OSHA:
No ingredients listed in this section

Section 4. FIRST AID MEASURES

EYE CONTACT: Not expected to require first aid measures.

SKIN CONTACT: Not expected to require first aid measures.

INGESTION: Not an expected route of overexposure.

INHALATION: Not an expected route of overexposure.

Section 5. FIRE-FIGHTING MEASURES

FLASH POINT: > 200°F This product is not flammable or combustible.

LOWER FLAMMABLE LIMIT: Not available UPPER FLAMMABLE LIMIT: Not available

AUTO-IGNITION TEMPERATURE: Not available

MATERIAL SAFETY DATA SHEET

EXTINGUISHING MEDIA: Use extinguishing media appropriate for the surrounding fire.

FIRE-FIGHTING INSTRUCTIONS: Exercise caution when fighting any chemical fire. A self-contained breathing apparatus and protective clothing are essential.

FIRE & EXPLOSION HAZARDS: Product emits toxic gases under fire conditions.

DECOMPOSITION PRODUCTS: Carbon monoxide; carbon dioxide, hydrogen chloride, ammonia, oxides of nitrogen.

NFPA RATINGS: Health = 0 Flammability = 0 Reactivity = 0 Special Hazard = None

Hazard rating scale: 0= Minimal 1= Slight 2= Moderate 3= Serious 4= Severe

Section 6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Wearing appropriate personal protective equipment, contain spill, collect onto inert absorbent and place into suitable container. Hose spill area well since product can make floors slippery.

Section 7. HANDLING AND STORAGE

HANDLING: As part of good industrial and personal hygiene and safety procedure, avoid all unnecessary exposure to the product and ensure prompt removal from eyes, skin and clothing.
Wash thoroughly after handling.
Keep container closed when not in use.

STORAGE: Product must be maintained at 38°F or higher. Protect from low temperatures.

Section 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

PERSONAL PROTECTIVE EQUIPMENT:

EYE/FACE PROTECTION: Chemical splash goggles recommended as a good industrial hygiene practice.
SKIN PROTECTION: No special requirement.
RESPIRATORY PROTECTION: None required.

ENGINEERING CONTROLS: No specific recommendations.

Section 9. PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT: > 212°F (> 100°C)

SOLUBILITY IN WATER: Complete

VAPOR PRESSURE: Similar to water

SPECIFIC GRAVITY: 1.02 - 1.04

VAPOR DENSITY (air= 1): Similar to water

pH: 6.0 - 8.0

MATERIAL SAFETY DATA SHEET

% VOLATILE BY WEIGHT: ~ 80 FREEZING POINT: Not available

APPEARANCE AND ODOR: Viscous, clear, colorless to pale yellow liquid

Section 10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable HAZARDOUS POLYMERIZATION: Will not occur

CONDITIONS TO AVOID: No specific information.

INCOMPATIBILITY: Strong acids and bases, carbon steel, copper

DECOMPOSITION PRODUCTS: Carbon monoxide, carbon dioxide, hydrogen chloride, ammonia, oxides of nitrogen.

Section 11. TOXICOLOGICAL INFORMATION

ON PRODUCT:
Oral LD50 (rat): 14.6 g/kg
Dermal LD50 (rabbit): > 20 g/kg (testing on a 40% solution of the polymer)
Eye irritation: A 40% solution of the polymer when instilled in rabbit eyes did not produce any ocular irritation during the 7-day observation period with the exception of one test eye in the no wash group at 24 hours which showed slight conjunctival effects.
Skin irritation: The primary skin irritation index (rabbits) for 40% solution of the polymer was found to be 1.0/8. Skin sensitization: Human patch testing on a higher molecular weight version of the polymer has shown that it is not a skin sensitizer.

ON INGREDIENTS:

Chemical Name	Oral LD_{50} (rat)	Dermal LD_{50} (rabbit)	Inhalation LC_{50} (rat)
No ingredients listed in this section			

Section 12. ECOLOGICAL INFORMATION

ON PRODUCT:
See information on polymer below.

ON INGREDIENTS:

Chemical Name	Aquatic Toxicity Data
Poly(dimethyldiallylammonium chloride)-40% solution	96 hr LC50 (bluegill sunfish): 0.82 - 1.3 ppm 96 hr LC50 (rainbow trout): 0.37 ppm 48 hr LC50 (Daphnia magna): 0.9 ppm (in clear water) 48 hr LC50 (Daphnia magna): 1.2 - 2.5 ppm (in 50 ppm clay suspension) 48 hr LC50 (Daphnia magna): 24.8 ppm (in 1000 ppm clay suspension) Note a substantial reduction in toxicity is observed under turbid conditions.

MATERIAL SAFETY DATA SHEET

Section 13. DISPOSAL CONSIDERATIONS

RCRA STATUS: Discarded product, as sold, would not be considered a RCRA Hazardous Waste.

DISPOSAL: Dispose of in accordance with local, state and federal regulations.

Section 14. TRANSPORT INFORMATION

DOT CLASSIFICATION:
Hazard Class: Not restricted
Proper Shipping Name: Not applicable
ID Number: Not applicable
Label: None

Section 15. REGULATORY INFORMATION

OSHA Hazard Communication Status: Nonhazardous
TSCA: The ingredients of this product are listed on the Toxic Substances Control Act (TSCA) Chemical Substances Inventory.
CERCLA reportable quantity of EPA hazardous substances in product:

Chemical	RQ
No ingredients listed in this section	

Product RQ: Not applicable (Notify EPA of product spills exceeding this amount.)

SARA TITLE III:

Section 302 Extremely Hazardous Substances:

Chemical Name	CAS #	RQ	TPQ
No ingredients listed in this section			

Section 311 and 312 Health and Physical Hazards:

Immediate	Delayed	Fire	Pressure	Reactivity
[no]	[no]	[no]	[no]	[no]

Section 313 Toxic Chemicals:

Chemical Name	CAS #	% by Weight
No ingredients listed in this section		

MATERIAL SAFETY DATA SHEET

Section 16. OTHER INFORMATION

HMIS RATINGS: Health = 0 Flammability = 0 - Reactivity = 0
Personal Protective Equipment = A

Hazard rating scale: 0=Minimal 1=Slight 2=Moderate 3=Serious 4=Severe

MSDS REVISION SUMMARY:

This MSDS has been revised in Section 9.

PREPARED BY: P.J. Maloney/J.P. Myers

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 001
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

VAN WATERS & ROGERS INC. , SUBSIDIARY OF UNIVAR (206)889-3400
6100 CARILLON POINT , KIRKLAND , WA 98033

---------- EMERGENCY ASSISTANCE ----------

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL - CHEMTREC
(800)424-9300

---------- FOR PRODUCT AND SALES INFORMATION ----------

CONTACT YOUR LOCAL VAN WATERS & ROGERS BRANCH OFFICE AT
VW&R KENT 206-872-5000 KENT , WA

****
PRODUCT IDENTIFICATION
****

PRODUCT NAME: FERRIC CHLORIDE SOLUTION

MSDS #: P1096VS

DATE ISSUED: 11/01/91

ISSUED BY: 009856

****
MANUFACTURER'S MSDS
****

EMERGENCY TELEPHONE
(313) 571-1100

Ferric Chloride Solution

****
PRODUCT INFORMATION:
****

Product Name Ferric Chloride Solution

REPORT NUMBER: 971
MSDS NO: P1096VS
EFFECTIVE DATE: 03/08/93

VAN WATERS & ROGERS INC.
MATERIAL SAFETY DATA SHEET

VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Chemical Name and Synonyms	Iron Chloride Solution
Chemical Family and Formula	Inorganic Salt Solution, FeCl3
CAS Registry Number	7705-08-0
DOT Proper Shipping Name	Ferric Chloride Solution
DOT Hazard Class and ID Number	Corrosive Material, UN 2582
US Clean Water Act Reportable Quantity	RQ - 1000 lbs. (454 kg)

****
HAZARDOUS INGREDIENTS:
****

	% by Wt.	Exposure Limits	OSHA Classification
Ferric Chloride	37-45	Not established	Irritant
Hydrochloric Acid	< .9		Corrosive
Ferrous Chloride	< .5		Irritant

****
PERSONAL PROTECTION AND EXPOSURE CONTROL:
****

Ventilation
Provide good general room ventilation to minimize exposure to vapors or mist.

Respiratory
Use NIOSH/MSHA approved, full face respirator as appropriate. Consult respirator manufacturer to determine appropriate equipment.

Eye Protection
Wear splashproof chemical safety goggles. Eyewash fountains recommended in all storage and handling areas. Do not wear contact lenses.

Skin Protection
Wear impervious rubber gloves and protective clothing to minimize skin contact. Full-face shield and rubber footwear, acid-resistant hood and full-body suit recommended as appropriate. Safety shower recommended in all storage and handling areas.

****
HEALTH-HAZARD INFORMATION:
****

DANGER - CORROSIVE, MAY CAUSE SEVERE BURNS TO EYES AND SKIN IRRITATION.

FIRST AID MEASURES:

Eyes

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 003
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Flush immediately with water for at least 15 minutes. Forcibly hold eyelids apart to ensure complete irrigation of eye/lid tissue. Get immediate medical attention.

Skin
Flush immediately with water for at least 15 minutes while removing contaminated clothing. Get immediate medical attention. Wash clothing before reuse.

Ingestion
Drink copious amounts of water. Do not induce vomiting. Get immediate medical attention.

Inhalation
Remove to fresh air. If not breathing, perform artificial respiration. Get medical attention.

Effects of Overexposure
Contact with liquid, mist, or vapor can cause immediate irritation or corrosive burns to all human tissue. Severity of the burn is generally determined by the concentration of the solution and duration of exposure. Contact with eyes may cause irritation and tearing and eye tissue discoloration, and may result in permanent visual loss unless removed quickly by thorough irrigation with water. Inhalation of concentrated vapor or mist may cause irritation of respiratory tract. Ingestion may cause liver and kidney damage, and may be fatal.

Toxicity
Oral LD50 (Rat): 900 mg/kg

****
PHYSICAL DATA:
****

Appearance and Odor	Reddish brown liquid, slight odor of iron/acid.
Solubility in Water	Complete
Vapor Pressure	Negligible
Specific Gravity (H2O= 1)	40% solution = 1.432 @ 17.5 Deg. C
Evaporation Rate (Butyl Acetate = 1)	>1
Boiling Point	110 Deg. C, 230 Deg. F
Melting Point, Deg. C	

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 004
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

(approx.) -50 Deg.

****
HANDLING AND STORAGE PRECAUTIONS:
****

Protect container from physical damage.
Do not strike containers or fittings with tools or hard objects.
Keep container closed and dry.
Store away from heat and oxidizing agents.
Wash thoroughly after handling.
Emptied container may retain vapor and product residue.

****
REACTIVITY DATA:
****

Conditions to Avoid
Material is stable when properly handled. Material is acidic and corrodes most metals. Avoid contact with strong alkalis and oxidizers.

Hazardous Decomposition Products
Decomposition/polymerization will not occur.

****
FIRE AND EXPLOSION HAZARDS:
****

Flash Point
Not flammable.

Fire Fighting and Personal Protection
Wear self-contained breathing apparatus and full protective clothing as appropriate for surrounding fire. Cool exterior of storage tanks.

Extinguishing Media
Use water spray, fog, foam, dry chemicals, CO2 or other agents as appropriate for surrounding fire.

Unusual Explosion Hazards
None.

****
SARA/TITLE III HAZARD CATEGORIES AND LISTS
****

Product Hazard Categories Lists

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 005
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

Chronic Health	YES	Extremely Hazardous Substance	NO
Acute Health	YES	CERCLA Hazardous Substance	YES
Fire Hazard	NO	Toxic Chemicals	YES
Pressure Hazard	NO		
Reactivity Hazard	YES		

NPCA - HMIS RATINGS
Health 3
Flammability 0
Reactivity 0
Personal protection to be supplied by user depending upon use conditions.

CANADIAN WHMIS CLASSIFICATION
D-1B; E

****
ENVIRONMENTAL PROTECTION:
****

Spill Control
Utilize full protective clothing including boots, and protective equipment as appropriate. Contain spill in order to prevent contamination of water way; neutralize with lime or soda ash. Flush with water in accordance with applicable regulations to waste treatment system. Spills of 1,000 lbs. or more must be reported to the National Response Center (800) 424-8802.

Waste Disposal
Dispose of spilled, neutralized, or waste product, contaminated soil and other contaminated materials in accordance with all local, state and federal regulations.

REPORT NUMBER: 971 VAN WATERS & ROGERS INC. PAGE: 004
MSDS NO: P1096VS MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/08/93 VERSION: 001

PRODUCT: FERRIC CHLORIDE SOLUTION

ORDER NO:
PROD NO :

FOR ADDITIONAL INFORMATION

CONTACT: MSDS COORDINATOR VW&R KENT
DURING BUSINESS HOURS, PACIFIC TIME (206)889-3400

09/21/93 12:15 PRODUCT: CUST NO: ORDER NO:

NOTICE

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IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE,

WITH RESPECT TO THE PRODUCT OR INFORMATION PROVIDED HEREIN. **

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* * * E N D O F M S D S * * *

9313044.3178

DON'T SAY IT --- *Write It!* DATE: 9-28-93

TO: John Locklair H4-67 FROM: E. M. Miller EMM R3-01

Telephone: 372-3832

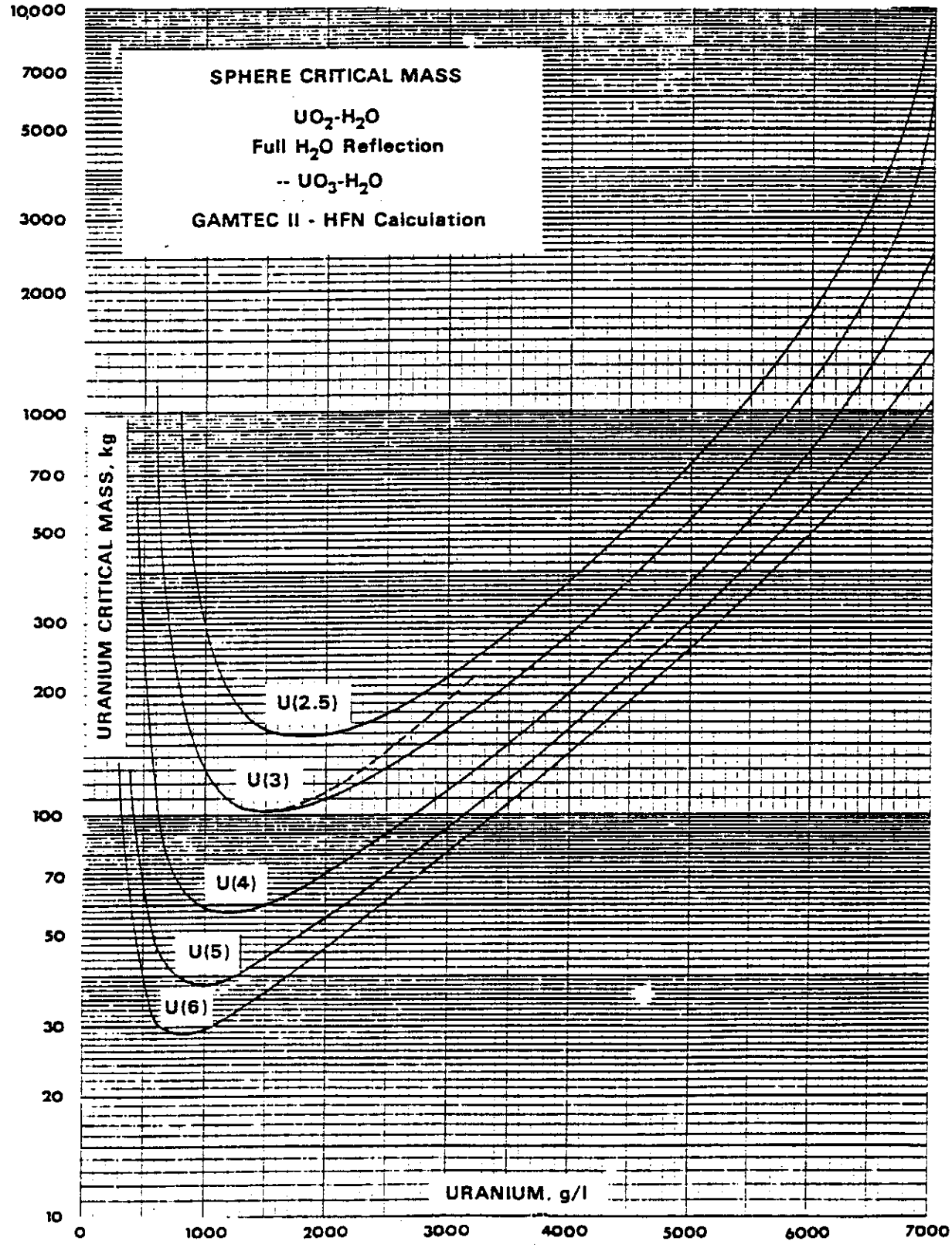
cc: D. E. Friar R3-01

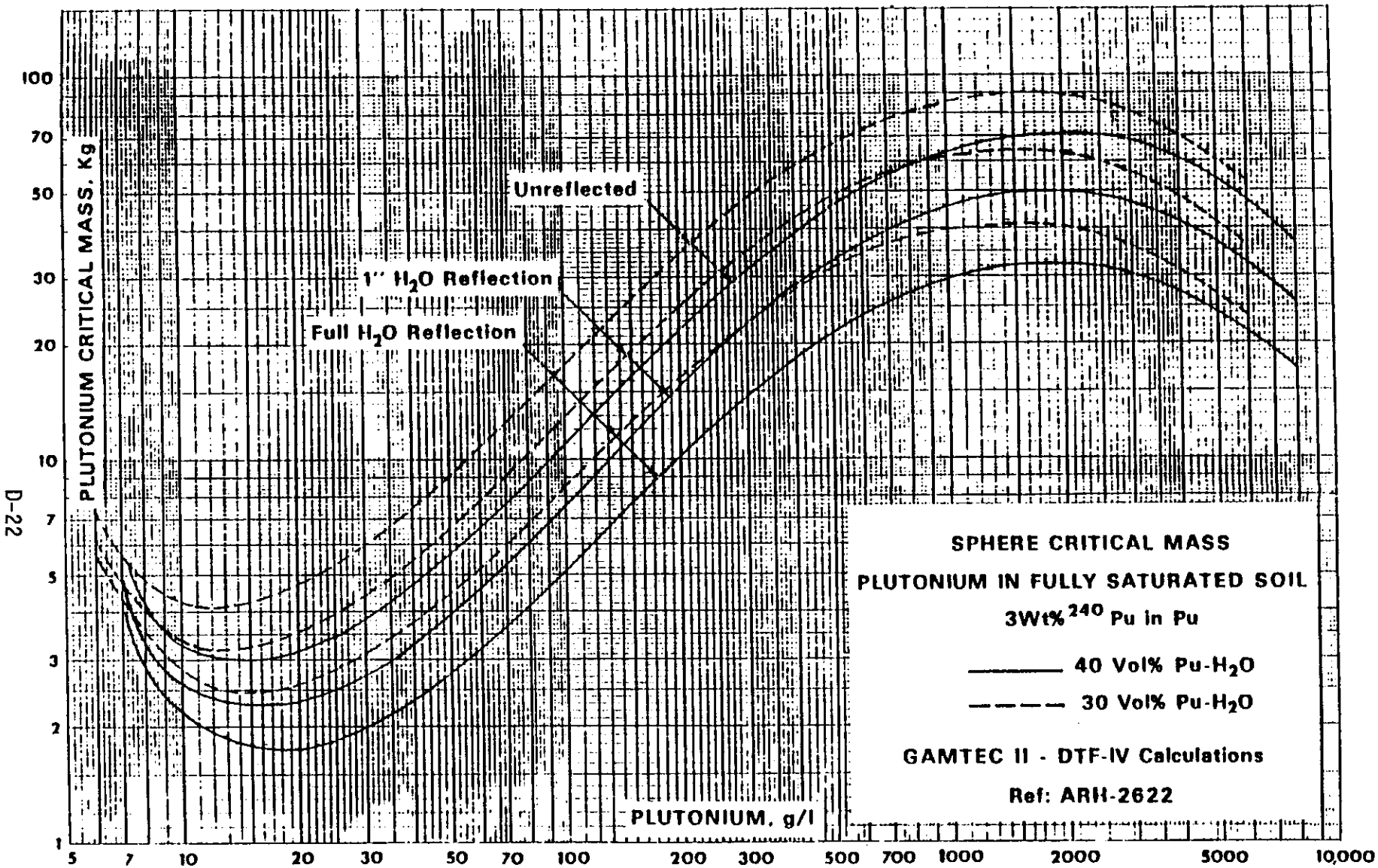
SUBJECT: WATER TREATMENT/SOIL WASH CRITICALITY ASSESSMENT

A CC:Mail message of 9/21/93 from John A. Locklair requested a criticality assessment of the cleanup treatment that will remove solids from the water stored in tanks that came from the 300 Area process trench soils treatment. The solids in the water are to be settled out with a polymer and ferric chloride treatment. The solids in a slurry are then to be pumped into water tight metal B-25 boxes. Based on a January 13, 1992, evaluation by Hans Toffer, the uranium enrichment in the solids is estimated to be 0.988 wt%. Using seven water samples, the average uranium concentration is 0.04 g/L in the water and the largest sample concentration was 0.094 g/L. Using the 1.51E5 liters of waste water to be treated and that the solids are to be put into four B-25 boxes, a 1.44 Kg average uranium mass would be in each box. The total volume of solids in the water are calculated to be 7,550 liters. The concentration and total mass of uranium in each box can be conservatively taken as 1 g/L and 4 Kg in a box. The solids are characterized as a small amount of contaminants attached to Hanford soil.

Uranium enriched to less than 1 wt%, homogeneously mixed with water can not go critical per Note 3 to Table 1-4, Section 1 of WHC-CM-4-29 and data in ARC-600. The solids are to be pumped to the water tight metal boxes as a slurry. Thus the solids will have plenty of water. Even if the box contents dried out, the water of hydration and intersticial water would remain. In addition, the iron and chlorine used to settle out the solids would add to the neutron absorption of the water. For a uranium concentration of less than 100 g/L, ARC-600 Figure III.B.6-6 (attached) shows that for an enrichment less than 2.5 wt% over a 1000 Kg of uranium in water is required for criticality. This is much larger than the 4 Kg estimated to be in a box. ARC-600 Figure III.A.6(97)-4 (attached) gives the critical mass for 97 wt% plutonium-239 in saturated Hanford soil. For plutonium concentrations less than 6 g/L at least 5.5 Kg of plutonium is required for criticality. For the boxes, the concentration is less than 1 g/L, the enrichment is less than 1 wt%, not 97 wt%, and the total mass is at most 4 Kg. Although plutonium and uranium do not act exactly alike, the margin between the calculated quantities required for criticality and those in the boxes is so great that the boxes can be judged to have an adequate margin of safety even if dried out. In all cases, the mass of fissile material in a box is less than a critical mass by at least a factor of 100.

Therefore, the water treatment proposed poses no possible risk of a criticality accident.




PLUTONIUM CRITICAL MASS, Kg
100
70
50
30
20
10
7
5
3
2
1
Unreflected
1" H_2O Reflection
Full H_2O Reflection
SPHERE CRITICAL MASS
PLUTONIUM IN FULLY SATURATED SOIL
3Wt% ^{240} Pu in Pu
40 Vol% Pu-H_2O
30 Vol% Pu-H_2O
GAMTEC II - DTF-IV Calculations
Ref: ARH-2622
PLUTONIUM, g/l
5
7
10
20
30
50
70
100
200
300
500
700
1000
2000
5000
10,000

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Project Title/Work Order:

WHC-SD-EN-SAD-005, REV. 1
Soil Physical Separations Treatability Safety Assessment For 100 and 300 Areas

EDT No.: ECN No.: 189909

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